A COMPARISON OF THE DECISION TABLE AND TREE

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The decision table and decision tree are essential tools for systems analysts ([6], [12]). These decision aids are used by systems analysts in depicting conditional logic for programmers and in validating this logic with the user. In addition, many authors recommend the decision table and tree as useful aids in decision making ([4, 11, 14, 21, 22]).

The effectiveness of the decision aids is determined by their ability to help in the understanding of conditional logic. Their relative effectiveness in facilitating such understanding however, has previously not been subject to proper empirical testing. Our research concerns the effectiveness of the decision table and tree in the user interface (i.e., we are interested in their relative effectiveness as communication tools in user validation of conditional logic and as decision aids in problem solving). Since these aids are normally applied in a specific context involving the users, we use a computer investment game that requires their use for decision making. A key feature of our research is the use of this computer game to promote highly motivated and engaged subjects.

The comparison of graphs and tables in their effect on interpretation accuracy [17] and their performance in the user interface ([20, 23, 24]), and the studies on graphs and their effects on decision-making ([1, 18]) are topics related to our research. However, the comparison of the table and tree at the user interface has not been examined. Thus, our research becomes significant.

Research Propositions

Gane and Sarson [12] propose that the decision table is better than the decision tree in the problem-solving task when the number of actions is large, many combinations of conditions exist, and there is a risk of ambiguities and omissions. They also argue that the tree solves simpler problems better as its pictorial vividness makes it more understandable.

Vessey and Weber [27] present an empirical examination of the structured tools—table, tree and structured English—in taxonomizing. The task of identifying the conditions that evoke actions is called taxonomization. They conducted a lab experiment to compare the effectiveness of structured English with that of the table and tree in facilitating the taxonomizing process. The study concluded that structured English outperformed the table and that the tree outperformed structured English in the taxonomizing process. Their experiment, however, did not explicitly compare the table with the tree. The focus of their study was the construction of the structured tools from a narrative description. The focus of our study, however, is in the interpretation of the structured tools. In other words, we focus on the user interface while Vessey and Weber focussed on the programmer interface. In order to compare the table and tree, we propose the following:

> **Proposition 1:** There is no significant difference between the effectiveness of the table and the tree in the interpretation of conditional logic.

In a comparison of the table and tree at the user interface, we need to consider the effect of relevant independent variables such as cognitive style, ability and background. The need to "fully consider the differential impact of other independent variables" has been emphasized in other experimental studies [17]. In this vein, we present a research framework in Figure 1 that depicts the relevant independent variables and their impact on the effectiveness of the decision aids.

Cognitive Style: The importance of cognitive style and the need to incorporate the decision maker's style is emphasized by [26]. Several studies in decision making have also examined the effects of cognitive style ([1, 7, 8, 13]). Cognitive style could be used to classify people as sensing or intuitive[1] [15]. We are interested in the comparison between sensing and intuitive personalities in their use of decision aids in

[1]Sensing: Preference for known facts; reliance on concrete data and experience. Intuitive: Looking for possibilities and relationships; focus on concepts and theory.

interpreting conditional logic. While sensing individuals are detail oriented, the intuitive individuals view the environment as a whole, and look for an understanding of the broader picture. Hence, we propose that:

> **Proposition 2A:** Cognitive style significantly influences the effectiveness of the decision aid in the interpretation of conditional logic.

The sensing or detail-oriented individuals may perform better than the intuitive or broad-picture personalities because the decision aids are geared toward people who can grasp details well. Hence, we propose that:

> **Proposition 2B:** Sensing personalities perform better than the intuitive personalities in interpreting conditional logic.

Academic ability and background: Academic ability (measured by GPA and SAT) and academic background of the subject are two important independent variables to be incorporated in studies involving student subjects. We believe academic ability will significantly influence the effectiveness of the decision aid because the skills needed for the interpretation of logic are often enhanced by academic ability. Hence, we propose:

> **Proposition 3:** The academic ability of the subject significantly influences the effectiveness of the decision aid in the interpretation of conditional logic.

We believe the academic background of the subject (business or computer science) should have no significant bearing on the effectiveness of the decision aid, since the interpretation of the decision aid is quite general and fits effectively with both the backgrounds. Hence, we state the following:

> **Proposition 4:** The academic background of the subject has no significant effect on the effectiveness of the decision aid in the interpretation of conditional logic.

Methodology

Operationalization: The treatment variables are the two decision aids—table and tree. The dependent variable is interpretation of the taxonomized conditional logic. The dependent variable is measured by the number of correct decisions made using each of the decision aids. The correct decisions are awarded points, and a cumulated score for each decision aid is its measure of effectiveness. The independent variables and their measures are depicted in Table 1.

The Myers-Briggs Type Indicator [MBTI] instrument was used to classify individuals as intuitive or sensing. This instrument is widely used to measure the perceptual orientation of people as it is a reliable and valid instrument [16].

Method: As previously stated, a key feature of our research is the use of a computer game to obtain highly motivated, engaged subjects. Motivation of subjects is an important factor that previous experimental designs may have failed to capture [19]. The game method was used earlier in [1] and a managerial simulation method was used in [2]. Our game scenario provides:

a) a strong motivation for subjects and keeps their interest in the experiment alive,
b) a context in real life that keeps the subjects engrossed while they are quite unaware of the experimental manipulation [absence of "Hawthorne Effect"], and
c) control for any experimenter variability as the computer game presents the material and records the responses of the subjects.

A pilot test of 15 subjects using the investment game revealed the issues of reliability and validity associated with the game method were indeed satisfied. In addition, the pilot test confirmed our contention that the game method promotes high motivation of subjects, as subjects were observed to be highly motivated and enthused. In the game the subjects take on the role of investors and arrive at investment decisions by interpreting the table or the tree. Their goal is to make profits by managing a portfolio of four mutual funds. The management of these funds requires the appropriate choice of buy and sell decisions as influenced by the market conditions. Subjects were trained on the use of the decision aids, to attain a uniformity of knowledge on the decision aids. A sample computer game was used to orient subjects to the investment game. The subjects were given enough time to familiarize themselves with the sample game. The computer game presents the investment scenario and market information to the subjects while automatically logging their responses. The subjects were asked to note their comments on any aspect of the game after it was completed.

The game enforces the following rules on its participants.

1) In each cycle, the market information triggers a decision from the investor.
2) The decision table/tree are provided to be used in managing the portfolio.
3) The game has eight cycles; the first four cycles are to be played with one decision aid and the latter four with the other.
4) The decision aid presents the "correct" answer to a portfolio decision triggered by the market information.
5) A fictitious sum of only $5,000 is provided to each subject for investment.
6) Cash made from a sale transaction cannot be held, but has to be reinvested.

These rules are made explicit to the subjects before the game begins.

After each cycle of the game, the subjects get the new prices of the funds, and the position of the portfolio with profits/losses, as a feedback for the investment decision. The game ends after eight cycles are played or after the expiry of 15 minutes, whichever is earlier.

Experimental Design: The recommended procedure to control for subject variability in the design of experiments is the within-subject procedure ([3, 25]). Each subject undergoes both treatments in order to control for subject variability. Thus, the design is counterbalanced to control for the order in which the treatments are administered. Table 2 shows group A receives the table first while group B gets the tree first.

Subjects: 67 undergraduate students with a business or a computer science background were used as subjects. Of those students, 34 were business majors and 33 were computer science majors. The MBTI test revealed there were 19 intuitive subjects and 48 sensing subjects. Group A had 33 subjects and group B had 34 subjects. The subjects were allotted to these groups in a random fashion. The subjects remained anonymous for the experiment.

Experimental materials: The experimental materials include the instructions, the decision table, the decision tree and the computer screen format presented to the subject. (The decision table and tree appear as the Appendix).

Results

A 0.05 level of significance is used for the t-tests and the Analysis of CoVariance (ANCOVA) used in the results section. Using t-tests, learning effects of the subjects were confirmed to be absent for the tree and the table. Each subject had four cycles of each decision aid with a maximum possible score of 4.0 on each aid. The mean and standard deviation of their tree and table scores are presented in Table 3. The standard deviations are relatively close, suggesting that both the decision aids have similar dispersion about their respective means.

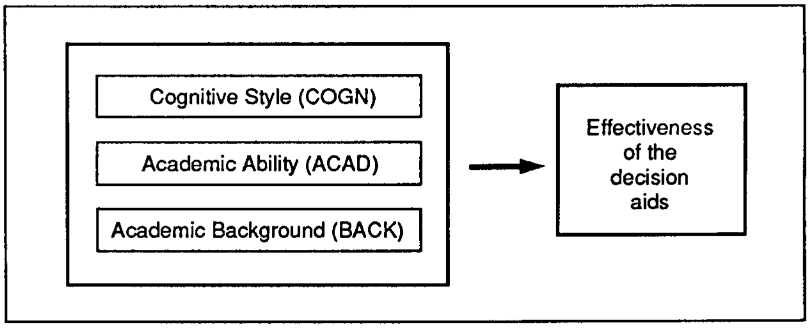


FIGURE 1.
Differential Impact of Other Independent Variables

TABLE 1.

Independent variable	Measure
Academic ability	GPA; SAT score
Academic background	Computer science (or) Business;
Cognitive style	Intuitive (or) Sensing;

TABLE 2.

	Treatments	
Group A	Table	Tree
Group B	Tree	Table

TABLE 3.

	Mean	Standard deviation
Table	2.2239	0.951
Tree	2.8358	0.963

TABLE 4.

	Mean	s.d.	Diff. mean	T-value	2-tail prob.
Tree score	2.8358	0.963	0.6119	4.73	<0.0001
Table score	2.2239	0.951			

Using the paired comparisons T-test procedure, Table 4 reveals the tree performs better than the table. The paired comparisons procedure is used, since the experimental design employed is the "subject as his/her own control" design. In this design, both treatments are administered to the subjects and the performance difference between the means of these treatments is tested for statistical significance.

This result fails to support Proposition 1 and provides statistical evidence that the tree is a better decision aid for the interpretation of conditional logic. This finding lends support to the proposition of [12] and the intuition of [27]. There is definitely a merit in the pictorial simplicity of the tree and its effectiveness in the presentation of conditional logic.

Explanations for the better presentation by the tree are:

- The desirability of graphically revealing the structure inherent in data or processes rather than using linear symbolic languages [12] and
- The ease with which a branch can be traced to its leaf node [28].

In order to test the entire model in Figure 1, we need to study the influence of the independent variables in the model on the tree and table. The Generalized Linear Model (GLM) procedure of SAS was used to model the variables in Figure 1 as follows and perform the ANCOVA. The GLM procedure is quite general and is recommended in the statistical literature for performing ANCOVA [9].

Tree as the dependent variable.

The model for this statistical analysis can be depicted as follows:

Tree = f (BACK, COGN, ACAD)

As depicted in Figure 1, the effectiveness of the tree is the dependent variable and BACK, COGN, and ACAD are the independent variables. This ANCOVA model looks for significant effects of each of these independent variables on the effectiveness of the tree. BACK, COGN and ACAD emerged *significant* at the 0.01 level. Proposition 2A (cognitive style), Proposition 3 (academic ability), and Proposition 4 (academic background), which state that these independent variables affect the effectiveness of the decision aids are confirmed.

In addition, we were interested in testing for significant differences in the means between a) the computer science and business students, and b) the sensing and intuitive subjects. The Scheffe contrast was used for this purpose. Computer science students report a mean score significantly greater (at the 0.01 level) than those of business students, supporting Proposition 4. This could be because the computer science curricula provides more emphasis on graphical tools to depict and interpret rules and logic. The sensing subjects also report a mean score significantly greater (0.01 level) than the intuitive subjects, supporting Proposition 2B.

Table as the dependent variable.

The model for this analysis can be depicted as follows:

Table = f (BACK, ACAD, COGN)

As in Figure 1, the effectiveness of the table is the dependent variable and BACK, ACAD, and COGN are the independent variables. Using ANCOVA analysis, COGN and ACAD were identified as *significant* effects at the 0.01 level. Proposition 2A (cognitive style), and Proposition 3 (academic ability), which state that these independent variables affect the effectiveness of the decision aids are confirmed.

The differences in the means between a) the computer science and business students, and b) the sensing and intuitive subjects were analyzed using the Scheffe contrast test. While there is no significant difference (0.01 level) between the scores of computer science and business students, the sensing subjects report a mean score significantly greater (0.01 level) than those of the intuitive subjects, supporting Proposition 2B. Since the table is used quite frequently in both the business and computer science curricula, the background of the subjects is not a significant effect in the interpretation of the table. Hence, it is not surprising to find no significant difference in the interpretation of this decision aid between the business and computer science students.

Future Research Directions

Practitioners keep pace with the development of new products by providing benchmarks and comparison of the products. For example, the advent of Computer-Aided Software Engineering (CASE) products was quickly followed by a benchmark of these products in [5]. In the same vein, researchers in software engineering need to systematically test generic tools (example, data flow diagram) and methods (example, prototyping) in experimental and field situations and keep pace with the innovation and prescription of these tools and methods. Our research is a step in that direction.

Motivation of subjects is an important factor that previous experimental studies may have failed to capture. We strongly believe the use of the computer game provided higher subject motivation and mitigated one of the major shortcomings of human factors experimentation. The game method, which ensures the motivation of the subjects through their active participation, should definitely be explored in future human factors research.

Future research should address the effectiveness of the decision tree in more complex situations. Paper and pen comparisons of more complex decision tables and trees artificially favor the table because of its more compact presentation. Computer-aided comparisons of complex tables and trees are possible when the decision tree appears on the computer screen and sufficient capabilities exist to explore the branches of the tree. In fact, automatic logging of responses, presenting experimental materials through the computer as a medium needs to be fostered in future human factors research. With the advent of CASE technology, we could use the computer to automatically collect valuable data on the use of these structured tools, enabling field studies that would cross-validate the results obtained from experiments. Such field studies could also provide an outlet for the empirical examination of software engineering tools and concepts. ◼

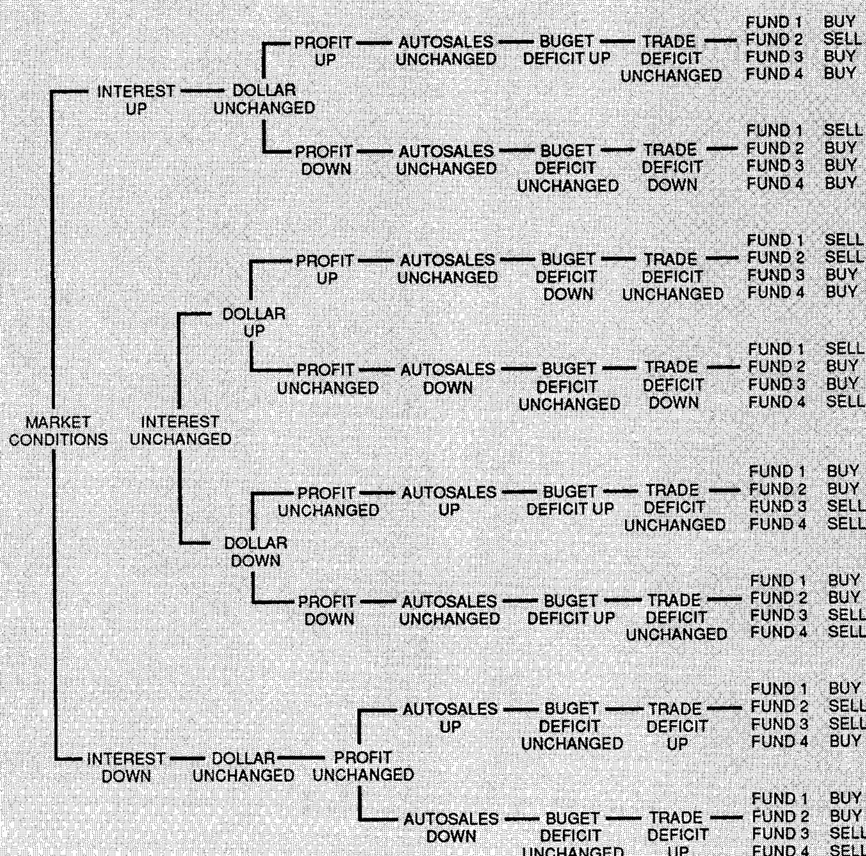
References

1. Benbasat, I. and Dexter, A.S. Individual differences in the use of decision support aids. *J. Account. Res.*

APPENDIX. Decision Aid for Investment Game

CONDITIONS								
INTEREST		DOWN		UP	UP			DOWN
DOLLAR	UP		DOWN			DOWN	UP	
PROFIT	UP			DOWN	UP	DOWN		
AUTO SALES		DOWN	UP				DOWN	UP
BUGET DEFICIT	DOWN		UP		UP	UP		
TRADE DEFICIT		UP		DOWN			DOWN	UP
ACTIONS								
FUND 1	SELL	BUY	BUY	SELL	BUY	BUY	SELL	BUY
FUND 2	SELL	BUY	BUY	BUY	SELL	BUY	BUY	SELL
FUND 3	BUY	SELL	SELL	BUY	BUY	SELL	BUY	SELL
FUND 4	BUY	SELL	SELL	BUY	BUY	SELL	SELL	BUY

Note: Blank Spaces against the conditions indicate that the condition is unchanged. The condition is changed only when is has a UP or a DOWN indicated against it. This point was emphasized by your instructor in your training session.



20, 1 (Spring 1982), 1–11.
2. Benbasat, I. Dexter, A.S. and Todd, P. The influence of color and graphical information presentation in a managerial decision simulation. *Human-Comput. Interaction 2,* 1 (Jan. 1986), 65–92.
3. Brooks, R.E. Studying programmer behavior experimentally: The problems of poor methodology. *Commun. ACM,* 23 (1980), 207–213.
4. Brosh, I. *Quantitative Techniques for Managerial Decision Making,* Reston Publishing Co., Va, 1985.
5. *Computerworld.* CASE tool kits workbenches, June 6, 1988.
6. De Marco, T. *Structured Analysis and Systems Specification.* Prentice-Hall, Englewood Cliffs, N.J., 1979.
7. De Waele, M. Managerial style and the design of decision aids, Ph.D. dissertation, University of California, Berkeley, 1978.
8. Doktor, R.H. and Hamilton, W.F. Cognitive style and the acceptance of management science recommendations. *Manage. Sci. 19,* 6 (Apr. 1973), 884–894.
9. Dunn, O.J. and Clark, V.A. *Applied Statistics: Analysis of Variance and Regression.* John Wiley and Sons, 1987.
10. Fitter, M. and Green, T.R.G. When do diagrams make good computer languages?. *Int. J. Man-Mach. Studies 11* (1979), 235–261.
11. Gallagher, C.A. and Watson, H.J. *Quantitative Methods for Business Decisions,* Mcgraw-Hill Book Co., 1980.
12. Gane, C. and Sarson, T. *Structured Systems Analysis: Tools and Techniques.* Prentice-Hall, Englewood Cliffs, N.J., 1979.
13. Ghani, J.A. The effects of information representation and modification on decision performance. Ph.D. dissertation, Wharton School, University of Pennsylvania, Aug. 1980.
14. Gregory, G. *Decision Analysis.* Pitman Publishing, London, 1988.
15. Jung, K. *Psychological Types.* London, 1923.
16. Keen, P.G.W. and Bronsema, G.S. Issues of cognitive style in MIS research. In *Proceedings of the First International Conference on Information Systems* (1980).
17. Liberatore, M.J., Titus, G.J., and Dixon, P.W. The effect of display formats on information systems design. *J. Manage. Inf. Syst. 5,* 3 (Winter 88–89), 85–100.
18. Lucas, H.C. An experimental investigation of the use of computer-based graphics in decision-making. *Manage. Sci. 27,* 7 (July 1981), 757–768.
19. Moher, T. and Schneider, M.G. Methodology and experimental research in software engineering. *Int. J. Man-Mach. Studies 16* (1982), 65–87.
20. Montazemi, A.R. and Wang, S. The effects of modes of information presentation on decision-making: A review and meta-analysis. *J. Manage. Inf. Sys. 5,* 3 (Winter 88–89), 101–127.
21. Moody, P.E. *Decision Making: Proven Methods for Better Decisions.* McGraw-Hill Book Co. 1983.
22. Pinney, W.E. and McWilliams, D.B. *Management Science: An Introduction to Quantitative Analysis for Management.* Harper and Row, N.Y., 1982.
23. Remus, W. An empirical investigation of the impact of graphical and tabular data presentations of decision making. *Manage. Sci. 30,* 5 (May 1984), 533–542.
24. Remus, W. A study of graphical and tabular displays and their interaction with environmental complexity. In *Manage. Sci. 33,* 9 (Sept. 1987), 1200–1204.
25. Sheil, B.A. The psychological study of programming. *Comput. Surv. 13* (1981), 101–120.
26. Taylor, R.N. and Benbasat, I. A critique of cognitive styles and research. In *Proceedings of the First International Conference on Information Systems* (1980).
27. Vessey, I. and Weber, R. Structured tools and conditional logic: An empirical investigation. *Communi. ACM 29,* 1 (1986), 48–57.

Categories and Subject Descriptors: D.2.2 [**Software Engineering**]: Tools and Techniques—*Decision tables;* D.2.10 [**Software Engineering**]: Design—*Methodologies, representation;* H.1.2 [**Information Systems**]: User/Machine Systems—*Human factors;* H.4.2 [**Information Systems Applications**]: Types of Systems—*Decision support;* K.6.1 [**Management of Computing and Information Systems**]: Project and People Management—*Systems analysis and design;* K.8 [**Personal Computing**]: Games

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