- These results are consistent with the notion that people with good visualization ability can construct a better internal model of the link architecture which enables them to navigate more efficiently through a hierarchical hypertext system.

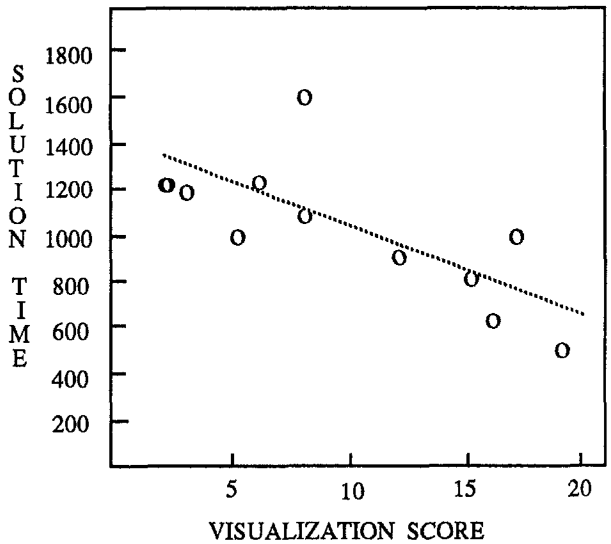

Figure 1. Scatterplot of solution time as a function of visualization score.

3. People learned a limited number of navigational features and stuck with them.

- In the laboratory study, over 95% of all pages viewed were selected either by double-clicking on a hypertext link or clicking the mouse on a paging button. Other methods of navigation (keyboard or menu functions) were infrequently used.
- In the customer site study, users also preferred to use the mouse but not to the same extent as observed in the laboratory study. Regardless of which mode of interaction they preferred, users rarely mixed mouse, keyboard, and menu functions, preferring to use one mode to the exclusion of the others. The order of preference in navigation modes (Table 1) was direct manipulation (mouse), keyboard function keys, and menu functions (rarely used).

	Laboratory Study	Site Study
Mouse Functions		
Double-click link traversal	684 (51)	318 (38)
Paging buttons	597 (45)	297 (36)
Keyboard Functions		
Keyboard paging	17 (1)	184 (22)
Menu Functions		
Menu paging	34 (2)	34 (4)
Menu link traversal	0	0
Total Interactions	1332	833

Table 1. Feature usage for the laboratory and site studies. Numbers in parentheses are percentage of total interactions.

Conclusions.

Keep it simple.

New users can, at best, acquire a handful of skills in their initial exposure to an application. The user interface should focus on combinations of a few, very simple operations and avoid asking users to master too many divergent conceptual and motor skills to begin using an application.

Help systems for new users should stress recognition over recall.

New users are most likely to employ simple, browsing strategies. They may be unwilling or unable to articulate their search objective in a way that would make keyword search (such as using indexes) useful. Help systems for new users should facilitate effective browsing.

Users may be constructing a spatial model of the hypertext link organization.

It is important to convey to the user a coherent, spatially-oriented model of the information architecture.

References.

Campagnoni, F.R. and Ehrlich K. (In press). Information retrieval using a hypertext help system. *ACM Transactions on Information Systems.*

Conklin, J. (1987). Hypertext: An introduction and survey. *IEEE Computer*, September, 17-41.

Marchionini, G. (1987). An invitation to browse: Designing full-text systems for novice users. *The Canadian Journal of Information Science*, **12**, 69-79.

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EXPECTED AND UNEXPECTED EFFECTS OF COMPUTER MEDIA ON GROUP DECISION MAKING

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Objective

During the past several years, a number of investigators have hypothesized that electronic mail and other computer-mediated communication technologies greatly attenuate social context cues (Hiltz and Turoff, 1978; Short, Williams, and Christie, 1976; Kiesler, Siegel, and McGuire, 1984). Equalization across status categories has been observed in studies of electronic communication in organizations (Sproull and Kiesler, 1986; Eveland and Bikson, 1988). The equalization phenomenon has been demonstrated in experiments showing that the distribution of discussion remarks was more equal when groups of peer members made decisions electronically than the same groups made decisions face-to-face (Siegel et al., 1986, McGuire et al., 1987; Weisband, 1989). However, no experimental test was made to examine the effect of electronic communication on preexisting differences in social status. The purpose of this study was to experimentally examine status equalization in computer-mediated group decision making.

Method

Twenty four groups, comprised of one graduate student (high status) and three freshmen (low status) of the same gender (15 male and 9 female groups), discussed four choice-dilemma problems of two different types (two graduate and two freshmen problems with presumably respective more expertise and experience of the high and low status members) and in two communication conditions (face-to-face and electronic mail). Experimental design was 2x2x2 (status x problem type x media) factorial repeated measures design with problems balanced separately and media balanced for each problem type.

The experimental procedure followed the "risky shift" paradigm (Kogan and Wallach, 1967; Siegel et al., 1986): (1) subjects indicated their private decisions for the four problems on the special questionnaire; (2) groups discussed each of the problems until a consensus was reached (two problems were discussed face-to-face and two were discussed electronically) and indicated the decision on the group form; (3) after each group decision was made the group members ware asked again to indicate their private preferences as well as to answer other questions in relation to subjects' perceptions of their and other group members' credibility, influence, and likability; (4) a final questionnaire was then given to assess subjects' comfort and prior experience with computer mail. Then the subjects were debriefed.

Prior to group discussions, group members introduced themselves to the group stating their first name, education status, what they did before coming to the school, and their favorite hobby. This part of status manipulation is based on the status generalization theory according to which an external, or ascribed statuses of group members (race, sex, age, occupation, education) are carried by people from group to group regardless of the group's specific task (Berger, 1972; Berger, et al., 1977; Webster and Driskell, 1978). Once imported, the external status is maintained as internal status of group members.

Dependent Measures and Hypotheses

Our dependent measures were: influence of group members on group decision and other group members attitudes; participation of group members in group discussion; and perception of group members' credibility, influence, and likability by themselves and other group members. We predicted that high status group members will have more influence on group decision and other group members attitudes, participate more in group discussions, and be perceived as more credible, influential, and likable than low status members. We also hypothesized that the ifluences of different statuses will be equalized by the electronic medium, and will be more equal for the freshmen problem type than for the graduate problem type.

Results

Analysis of variance (GLM in SAS) supported our predictions of the influence of status for most of the dependent measures. Also as it was predicted, we observed a significant equalizing effect of electronic medium on both actual and perceived performance of the high and low status members. Three typical patterns of the equalization were observed: (1) values for different statuses changed in opposite directions (for some measures becoming almost equal), (2) values for different statuses changed in the same direction but at a different rate, and (3) values for the high status lowered while the values for the low status stayed almost unchanged. An important unexpected finding was that, contrary to our predictions, electronic media had an equalizing effect on the difference in expertise and experience as well. In the face-to-face condition graduate students were more active and influential and were perceived as more credible and influential when graduate issues were discussed than when freshmen issues were discussed. This differences were lessened or completely disappeared in electronic discussions.

Conclusion

It appears that, contrary to the conventional wisdom, electronic media does not filter out social and personal factors while emphasizes such factors as knowledge and expertise. This study suggests that the computer medium is not a filter of social and personal differences, but rather an indiscriminating "muffler" of all differences. The main practical implication of this finding is that if we want to retain influence of certain factors while using electronic media for group decision making, we must provide appropriate means and devices for communicating the differences through the media.

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Selected Reference

Berger, J. (1972). *Status characteristics and social interaction.* **American Sociological Review** 37, 241-255.

Berger, J., Fisek, M.H., Norman, R.Z., and Selditch, M. (1977). **Status Characteristics and Social Interaction: An Expectation States Approach.** New York: Elsevier.

Eveland, J.D. and Bikson, T.K. (1988). *Work group structures and computer support: A field experiment.* **Transactions on Office Information Systems.** 5, 354-379.

Hiltz, S.R. and Turoff, M. (1978). **The Network Nation: Human Communication Via Computer**. Reading, MA: Addison-Wesley.

Kiesler, S., Siegel, J., and McGuire, T. (1984). *Social Psychological Aspects of Computer-Mediated Communication.* **American Psychologist**, 39(10), 1123-1134.

Kogan, N. and Wallach, M.A. (1967). *Effects of physical separation of group decision-makers upon group risk taking.* **Human Relations**, 20, 41-49.

McGuire, T.W., Kiesler, S., and Siegel, J. (1987). *Group and computer-mediated discussion effects in risk decision making.* **Journal of Personality and Social Psychology**, 52(5), 917-930.

Short, J.A., Williams, E., and Christie, B. (1976). **The Social Psychology of Telecommunications**. London: Wiley International.

Siegel, J., Dubrovsky, V., Kiesler, S., and McGuire, T. W. (1986). *Group Processes in Computer-Mediated Communication.* **Organizational Behavior And Human Decision Processes** 37, 157-187.

Sproull, L. and Kiesler, S. (1986). *Reducing social context cues: Electronic Mail in organizational communication.* **Management Science** 32(11), 1492-1512.

Webster, M. and Driskell, J.E. (1978). *Status Generalization: A Review and Some New Data.* **American Sociological Review** 43, 220-236.

Weisband, S.P. (1989). **Discussion advocacy and computer-mediated communication effects in group decision making.** Unpublished doctoral dissertation, Carnegie Mellon University, Pittsburgh, PA.

COMPREHENSION OF PASCAL STATEMENTS BY NOVICE AND EXPERT PROGRAMMERS

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Introduction

The principles of cognitive psychology and human factors have been successfully applied to many aspects of human-computer interaction. Nevertheless, programming remains a difficult task. Researchers suggest that programming is a cognitively demanding task because of its inherent problem-solving nature (Nickerson, 1986; Anderson, 1985). Previous work has shown that comprehension of Basic statements depends on both the macrostructure and the microstructure of the statement (Dyck & Mayer, 1985).

Macrostructure is a statement's context. Soloway et al. have shown that novices possess misconceptions about the ways that variables can be used (i.e., 'read', 'counter', and 'running total' variables), and about the Pascal looping statements (while, for, repeat) (Soloway, Ehrlich, Bonar, & Greenspan, 1982).

Microstructure refers to transactions, or the units into which a statement A transaction is defined as "a unit of programming knowledge in which a general operation is applied to an object at a general location" (Mayer 1979b). Formally, a transaction is a triple composed of an operation (e.g., MOVE, ERASE), an object (e.g., number), and a location (e.g., memory address, output screen). These transactions correspond to the cognitive processes that occur when Basic statements are comprehended. Appendix A contains the example Basic statement, LET A = A + 1 and its transactions.

Pascal statements have been examined in terms of macrostructure (Soloway et al., 1982), but not in terms of the microstructure.

Two goals motivated this pilot study:

1. Develop micro-level analyses of Pascal statements
2. Look for expert-novice differences in micro-level comprehension of Pascal statements

Transactions were developed for a set of Pascal statements. For example, the statement

I:= maxint;

is composed of the following transactions

1. Obtain the value of maxint.
   (FIND, number, memory location)
2. Erase current value in memory space I.
   (DESTROY, number, memory location)
3. Store the result of step 1 in memory space I.
   (CREATE, number, memory location)

Method

Subjects

Twenty-six computer science students participated in this study. Students were categorized as either novices or experts. The 14 novices were currently completing an introductory course in Pascal programming. The 12 experts were senior computer science majors. Subjects were paid $5 for their participation.

Materials

Twenty-five Pascal statements were chosen by the authors, one of whom regularly teaches an introductory pascal programming course at CSUF. These statements were representative of common statements and covered a range of difficulty.

For example, some statements used were

1. I := maxint;
2. readln (I);
3. while J < 10 do J:= J + 2;
4. A[I] := A[I] + 1;
5. type C = (F, G, P);

Appendix B contains all 25 statements.

A set of transactions was developed for each statement based on Mayer's (1979a; 1979b) transactions for Basic.