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ABSTRACT

This paper examines the search and selection strategies of teachers when retrieving information on computer assisted learning programs from an online database. A literature review covers cognitive factors in human computer interactions, database query and manipulation, cognitive style, and information searching. Several experiments are reported that tested the disembedding effect of the presence of keywords in entries about computer assisted instruction programs and the influence of teachers' cognitive style upon their search strategy and their success at retrieving appropriate information. Results are reported from a study with 77 undergraduate education students which indicate that the presence of keywords aids field dependent teachers when completing the tasks. The implications of these findings for the design of computer software are discussed. The report includes 5 figures, 8 tables, and 28 references. (Author/LMM)

Teacher Cognitive Styles and Selection of Computer Courseware

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Abstract

This paper examines the search and selection strategies of teachers when retrieving information stored in a database concerning computer assisted learning programs. It reports several experiments designed to test the disembedding effect of the presence of keywords in entries about CAL programs, and the influence of teachers' cognitive style upon their search strategy and their success at retrieving appropriate information. Results indicate that the presence of keywords aid field dependent teachers when completeing the tasks. The implications of these findings for the design of computer software are discussed.

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Computers have the potential to make large amounts of information available to users. Little attention has been given to examining individual differences exhibited by novice computer users in seeking information from a database, and to the effect these differences have on the information seeking performance and strategies of users. The purpose of this study, therefore, was to the examine information seeking behaviour of novice computer users and to assess the extent to which the provision of a search-aid hindered or facilitated success at information selection. In particular, attention was paid to the relationship between the provision of search-aids (such as keywords), cognitive styles of computer users (field dependence), and the strategies used to determine the adequacy of educational computer software for use in teaching.

This study dealt with the information search and retrieval performance and strategies of instructors when required to access information about Computer Assisted Learning (CAL) software presented "on-line", and then make decisions about the match between materials found and their appropriateness to teaching situations. Research into information processing has focussed upon the aptitudes of the searchers and their interaction with the materials. Cronbach and Snow (1977) pointed out the problems in searching out information highlighting searchers whose search strategies were hindered by being forced to use a strategy at variance with their intuitive strategies. The present study examined information search and retrieval performance and strategies of instructors in the context of CAL selection in order that computerised information system design variables which match human and computer information processing may be identified, and more may be understood about the cognitive processes of instructor planning when using CAL software.

Human-Computer Interaction: Cognitive Factors

A computer assisted information system consists of three major components: hardware, software, and the user. The interaction of the three components is one of the important parts of the system - the human-computer interface. As noted by Bo (1982), computers have considerable power for data manipulation, and if a database is built efficiently, they can store, manipulate, and retrieve huge amounts of detailed information; but the user is far better at extracting significant information. A goal for system designers must be to examine the ways in which attributes of computer systems can be matched with human retrieval skills, especially the cognitive factors which facilitate information retrieval.

Shneiderman (1982) has amplified this message when calling for systematic design, testing, and implementing the user interface, especially if the interests of novice users are to be served.

While an appropriate interface will not remove either the anxiety or lack of knowledge of novice computer users, it will make effective interaction more probable.

Novice and expert users generally exhibit quite different modes of behaviour (Moran, 1981). The novice usually is engaged in problem solving activity whereas the expert is skilled in interacting with the computer. Interaction, for the expert user, is a routine cognitive skill (Card, Moran & Newell, 1980). Moran believes that the only way to attain a coherent understanding of the user is to look beyond the superficial features of the computer system and consider the user in psychological terms. He adds that the most promising approach may be the application of information processing models which spell out the mental operations that the user must go through to accomplish given tasks. This lead has been followed up with respect to computing experience. To describe different levels of computer-user sophistication, Schneider (1982) has developed a user taxonomy and identified levels: Parrot, Novice, Intermediate, Expert; and Master.

For Schneider each level is characterised by the chunk size assumed to be employed by the user, language scope, and the degree of generalization or abstraction of concepts. This taxonomy can be conceptualised as a development of Shiffrin and Schneider's (1977) earlier distinction between controlled and automatic information processing. Schneider has thus identified a useful means of describing the different cognitive processes with which people of varying levels of computing experience interact with computer systems.

Database Query and Manipulation

One of the most fruitful areas for studying cognitive processes may be in database query. Given that users of database systems require manipulation languages for operating on the database, Zloof (1978) listed nine requirements for the design of user-friendly data manipulation languages for non-programmers:

1. Minimum concepts required to get started: simple operations should be simple.
2. Minimum syntax: simple syntax, even for complex operations.
3. Consistency: operations should have consistent semantics in all contexts.
4. Flexibility: language should "capture" the users' thought processes, thus providing many degrees of freedom in formulating a transaction.
5. Not sensitive: a small change in the query should produce a small change in the query language expression.
6. Easy to extend and modify: views, snapshots and reorganisations.
7. Minimum exception rules: uniform language structure.
8. Easy detection of errors: minimise possibility of error and provide good error messages.
9. Unified language: same syntax for query, update, definition, and security control.

This list represents a useful set of guidelines for the evaluation of manipulation or query language design, but most factors remain untested.

Several methods can be used to retrieve information from large databases: menu selection, keyword search, special query languages, and so-called "natural" languages specification.

1. Menu selection schemes are designed primarily for non-specialist users - specifications of search requests depends upon recognition. Problems with this type of organisation include mis-match of word meanings and categorisations, inflexibility and tediousness of use.
2. Keyword systems search on user provided single words or combination of words. Studies have shown that knowledge of the cataloguing system and the content area can be necessary to the selection of appropriate keywords (Stevens & Shneiderman, 1981, cited by Dumais & Landauer, 1982).
3. Special database query languages are very powerful for well-trained users, but are not suited to casual users.
4. Natural languages have the advantage that a specific query language need not be learned by users. On the other hand, such languages are very expensive to develop.

A continuing problem for information system designers is that users' natural logic often differs markedly from formal logic (Braine, 1978). It is difficult to design a database system around users' natural logic, as individuals are not always consistent in their logic.

Cognitive Style

The concept of cognitive style refers to psychological dimensions that represent consistencies in an individual's manner of acquiring and processing information. More specifically, it concerns individual differences in the cognitive processes by which knowledge is acquired: perception, thought, memory, imagery and problem-solving (Ausburn & Ausburn, 1978). In particular, the field independent/field dependent dimension of cognitive style, which has been thoroughly explored by Witkin, Moore, Goodenough and Cox (1977), concerns the ability to deal with embeddedness in a stimulus field. Further studies by Witkin, Oltman, Raskin and Karp (1971) have revealed that field independent individuals have more analytical and structuring abilities compared to field dependent types. As put by Benbasat and Taylor (1982), central to Witkin's theory is the contention that the ability to "break-up" a configuration reflects not only perception, but also indicates a basic approach to problem solving.

Cognitive Style and Information Searching

There are few research studies that have dealt directly with the relationship between field dependence/independence and information selection and use. In an experimental study (Bariff and Lusk, 1977) the same information was presented to decision makers in four different report formats: tabular raw data, percentage data, histogram and ogive report (which showed cumulative frequencies). These formats were reasoned to be ranked in increasing complexity. The results showed that field dependent subjects' format preferences were inversely related to increasing levels of report complexity. Similarly, Benbasat and Dexter (1979) found that field independent subjects performed equally well with aggregated or disaggregated data reports in a laboratory study using a relatively structured inventory production decision making task. Field dependent subjects who were given aggregated data reports had the worst average profit performance among all subjects.

These two studies indicated that field dependents both prefer and perform better when the information presented to them is in relatively untransformed, non-aggregated raw form. These findings are consistent with Witkin's theory that field dependents have difficulty in disembedding a complex figure or concept, therefore leading to a preference for disaggregated data.

In another study again using production decision making tasks, Benbasat and Dexter (1979) analysed the influence of field dependence on the use of a computer simulation model as a decision aid. While keeping some variables constant, the decision maker could alter one or more of the other variables in order to determine the effect of the change on profit performance. Benbasat and Dexter predicted that a simulation model would provide the ability to analyse separately the impact of each decision variable (or groups of variables) on profit performance. The simulation model thus provided field dependents a means of isolating (disembedding) the influence of single (or few) variables from the more complex five-variable set which determined profit performance. The results indicated that field dependents, who performed substantially worse than field independents without the simulation model, improved their performance to the level of field independents with the simulation model, a result which is also consistent with Witkin's theory.

In an extension of the Bariff and Lusk (1977) study, Lusk (1979) asked subjects to answer a number of questions using data provided in reports which ranged from tabular to graphic in various levels of complexity. Since the task required disembedding of information from reports, Lusk hypothesised that field independents would perform better than field dependents. Whilst this was found to be true, however, the results also showed that regardless of cognitive style, individuals using less transformed (less complex) reports performed better.

In summary, the experimental evidence indicates that although field independents perform equally well with raw or transformed/aggregated data, field dependents prefer and perform better when they are provided with disaggregated data reports or decision aids which help in disembedding the critical elements of complex problems. These results also support the suggestion of Salomon (1971 & 1979) that particular cognitive skills can be supplanted in persons deficient in that skill: the case in point being the ability of field dependent persons to disembed complex information.

The present study focussed on the provision of keywords as a search-aid and disembedding agent. Following the research reported above, it was anticipated that field dependent persons would perform better when provided with keywords but that field independent persons would perform equally well with or without this disembedding search-aid.

Major Questions

Thus, the major questions of the study were:

1. Does the provision of keywords as an on-line search-aid facilitate search and selection performance from a computerised information system?
2. Does field dependence predict search and selection performance from a computerised information system?
3. Do subjects with different field dependence scores perform differently when interrogating a computerised information system with and without the search-aid of keywords?
4. Does the provision of keywords as an on-line search-aid influence subjects' search and selection strategy when interrogating a computerised information system?
5. Does field dependence predict subjects' search strategy when interrogating a computerised information system?
6. Do subjects with different field dependence scores adopt different search strategies when interrogating a computerised information system with and without the search-aid of keywords?

METHOD

Seventy seven undergraduate students enrolled in Undergraduate College Education courses were used as subjects in this study. The age range of these students was 18 through to 54. The mean age was 29.6 and the standard deviation was 9.2. The sample was approximately equally divided between males (N = 40) and females (N = 37). Whilst approximately half were enrolled in an educational computing class (N

= 38), most subjects (N = 43) located themselves on the lowest rating of a five point computing experience scale ranging from "little to none" to "regular use". The remaining subjects placed themselves on other points (N = 13; N = 10; N = 6; N = 3 respectively) to produce a positively skewed distribution.

A 2 x 2 factorial design with repeated measures over the treatment variable was used in this study. The two treatment conditions were with and without keywords, and field dependence was regarded as a moderator variable. The experimental design is shown in Figure 1.

Insert Figure 1 about here

Each subject completed two search and selection tasks; in all cases the mathematics task preceeded the biology task. Subjects were randomly assigned to two treatment groups: mathematics task with keywords (MKW), biology task without keyords ($B\overline{KW}$); and mathematics task without keywords ($M\overline{KW}$), biology task with keywords (BKW). The observations consisted of scores on a number of dependent measures: number of relevant selections, search time, relevant selections per minute, proportion of multiple search requests and search profile group membership. For the first five dependent measures a regression equation was calculated with all covariates entered into the model. The covariates were entered into a discriminant analysis to predict search profile group membership.

Experimental Materials

A database which contained some two hundred and thirty entries about CAL programs was prepared. The programs referred to in the database entries were available on the same timesharing computer system used for training and testing, and were selected from commercially and student produced programs available on the system. Each entry on the database had two possible display formats: One version displayed research number, name of the CAL program, keywords, and an abstract about the program. The other version omitted keywords. Two versions of a query program which accessed the database were prepared. One version of this program allowed subjects to interrogate each of the name, keyword, and abstract sections of the database. This query program activated the display of keywords in each entry. The other version of the query program did not access the keywords section of the database, and did not activate the display of keywords.

Procedures

Subjects were trained in the use of the query program and tested in their class groups. In all, six separate class groups whose size ranged from five to nineteen were trained and tested. Each three hour training and testing session took place in subjects' normal class time. All training and testing was completed over a three week period. At the beginning of each training session subjects were randomly allocated a numbered test booklet which contained information used in training, practice examples, experimental tasks, response forms for testing computing experiments, keyboard expertise, and mathematics and biology background. There was also provision for subjects to make notes when completing each experimental task. The test response form required subjects to keep a record of the database record number and name of each program called and the number, name and comments about each program finally selected. Even numbered booklets indicated that subjects used the "keywords" treatment for the mathematics task and "without keywords" treatment for the biology task. Odd numbered booklets indicated subjects used the "without keywords" treatment for the mathematics task and the "keywords" treatment for the biology task.

All subjects received training in the operation of the computer terminals and use of the query program. Prior to moving to the computer terminals the Group Embedded Figures Test (Witkin et al, 1971) was administered according to the established procedures of this test. All subjects then completed two practice searches, using each of the treatment conditions. Assistance was given when required. Depending on availability, subjects chose to use either a VDU (N = 47) or hardcopy terminal (N = 30). Each subject used the same medium for practice and experimental tasks.

The experimental tasks were introduced when all subjects could satisfactorily operate the query program. Subjects were informed that while all search information was being recorded by the computer, all results of testing would be held in confidence and would not be counted toward their course grade.

Once logged into the computer and into one or other of the query programs, subjects were prompted with "Search, List, Help or End?", to which they could respond with S, L, H or E. The response E ended the search, whilst H provided two "pages" (screensfull) of information about each query program's operation. The response L enabled subjects to "list" either one or a range of database entries by specifying its record number or a range of recorded numbers. An example of the last response is "L 1-30", in which case the subjects would have seen database entries 1 to 30. The S response indicated the subjects wished to undertake a search of the name, keywords (if allowed) and/or abstract sections of the database. Once into the search subroutine, subjects were required to specify which section of the database they wished to interrogate by placing an A, K, or N before each search string requested. Each search string had to be placed in quotation marks. Searches could be combined with the logicals "and", "not" and "or". An example search request was K "mathematics" and A "addition" or A "adding" not A "fractions".

Following testing several subjects from each group were interviewed. They were asked to describe the manner in which they interrogated the database and difficulties experienced.

Data Analysis

Stepwise multivariate regression across the dependent measures relevant selections score, search time, relevant selections per minute, number of requests, and proportion of multiple requests was estimated for both tasks with the subprogram NEW REGRESSION of the Statistics Package for the Social Sciences. The predictors treatment, field dependence, treatment by field dependence interaction, computing experience, keyboard expertise, mathematics or biology background (depending upon task), and medium used were entered into the equation for both tasks. Non-significant covariates (F ratio $p > .05$) were deleted from the model.

Thus, the statistical model used for testing the hypotheses was:

$$Y' = A + B_1X_1 + B_2X_2 + B_{12}X_{12} + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6$$

where Y' = dependent variable for each task: relevant selections score, search time, relevant selections per minute, and proportion of multiple requests.

X_1 = main effect for treatment
X_2 = main effect for field dependence
X_{12} = interaction effect of treatment and field dependence
X_3 = main effect for computing experience
X_4 = main effect for keyboard expertise
X_5 = main effect for mathematics or biology background
X_6 = main effect for medium used

Each subject's search profiles (observed at two minute intervals) were coded for use with a hierarchical group analysis program which was developed by Veldman (1967) following the work of Ward (1963) and Ward and Hook (1963).

RESULTS

Table 1 presents means and standard deviations for variables used in the analyses. In this Table, computing experience, keyboard expertise and mathematics and biology background were derived from the instruments set out in the training/testing booklet.

Insert Table 1 about here

Table 2 presents means and standard deviations of the two treatment groups by criterion means for both tasks. The overall means and standard deviations are also shown. While none of the differences between treatments are significant at the 0.05 confidence level, subjects provided with the use of keywords made more requests (mathematics task: KW 4.71, $\overline{KW}$ 3.78; biology task: KW 7.57, $\overline{KW}$ 5.86) and made more multiple requests (mathematics task: KW 0.35, $\overline{KW}$ 0.26; biology task: KW 0.38, $\overline{KW}$ 0.29). Subjects provided with keywords made slightly more relevant selections in the mathematics task (KW 2.24, $\overline{KW}$ 2.21), but the opposite was true in the biology task (KW 2.13, $\overline{KW}$ 2.53). These results indicated that while some of the predicted trends are present, the provision of keywords alone makes no significant difference to the dependent variables as measured in this study. They also indicated that there may have been some task related differences in this study. In the biology task subjects searched longer, made more requests but less relevant selections per minute.

Insert Table 2 about here

Further examination of subjects' search requests revealed that when provided with keywords fifteen subjects in the mathematics task and seven subjects in the biology task did not make a keyword request. These subjects therefore did not experience the treatment as defined by this study, and when they were removed from the analysis a different pattern of results emerged. Table 3 presents means and standard deviations of the two treatment groups by criterion measures for both tasks excluding these subjects. In both tasks, those subjects using keywords made significantly more requests (mathematics task: KW 5.48, $\overline{KW}$ 3.78, $p < .05$; biology task: KW 8.03, $\overline{KW}$ 5.86, $p < .05$). Further, in the mathematics task, those subjects who used keywords made a significantly higher proportion of multiple requests (KW 0.56, $\overline{KW}$ 0.26, $p < .05$). These results indicated that the actual use of keywords alone significantly influences subjects' search strategy, but does not significantly affect selection performance. Further analysis revealed that those who did not make a keyword search when permitted in the mathematics task had significantly more mathematics background, but this finding was not confirmed for the biology task.

Insert Table 3 about here

Selection Performance

It was hypothesised that treatment, field dependence, and the treatment by field dependence interaction would be significantly related to the number of relevant selections made in both tasks.

The multivariate regression analysis including those subjects who did not use keywords when provided suggested that none of these predictions could be accepted at the 0.05 confidence level. Treatment and field dependence main effects were not significant in the reduced model. The first order field dependence by treatment interaction was also non-significant. The covariate content area background was a significant predictor in both tasks (mathematics task: B = 0.383, F = 6.023 [4, 68], $p < .05$; biology task: B = 0.310, F = 4.205 [4, 69], $p < .05$). Both variables also accounted for significant amounts of estimated variance of this dependent measure, 10% for mathematics background, and nearly 6% for biology background.

As previously mentioned, fifteen subjects in the mathematics task and seven subjects in the biology task did not use keywords when provided. Table 4, which shows the reduced regression model with these subjects removed from the analysis, confirms the treatment and field dependence main effects were non-significant at the 0.05 confidence level in both tasks. The first order field dependence by treatment interaction was also non-significant in this model. The covariate computing experience was a significant predictor in the mathematics task and accounted for 8% of the estimated variance of this dependent measure.

Insert Table 4 about here

These results therefore indicated that neither the provision of keywords or their actual use, field dependence, or the interaction of field dependence and provision/use of keywords significantly predicted the number of relevant selections made by subjects when searching the database.

Search Time

The multivariate regression analysis including subjects who did not use keywords when provided suggested that none of these predictions could be rejected at the 0.05 level of confidence. The expected main effects and field dependence by treatment interaction were not found in the reduced model. Further, none of the covariates were significant predictors in either task.

The multivariate regression analysis excluding those subjects who did not use keywords when provided suggested very different trends (Table 5). The main effects for treatment, field dependence and the field dependence by treatment interaction were all significant at the 0.05 confidence level in the reduced model for the mathematics task. Further, the field dependence by treatment interaction accounted for 15% of the estimated variance for search time in this task. While none of these significant effects were observed for the biology task, field dependence accounted for approximately 7% of the estimated variance of this dependent measure. The large differential effect of the treatment between tasks suggested that those subjects who did not make a keyword request when permitted searched for less time in the mathematics task but longer in the biology task.

Insert Table 5 about here

These results therefore indicated that in the mathematics task those subjects who actually used keywords when provided to interrogate the database used significantly more search time than those not using keywords. They also indicated that in the same task field independent subjects used significantly less search time than field dependent subjects.

The field dependence by treatment interaction for the mathematics task was disordinal (Figure 2), and indicated that field dependent subjects not using keywords used less search time than those using keywords, and that field independent subjects using keywords used less search time than those not using keywords.

Insert Figure 2 about here

Search Efficiency

The multivariate regression analysis including those subjects who did not use keywords when provided suggested that none of these predictions could be supported. The expected treatment and field dependence main effects and interaction were not found in the reduced model. The covariates computing experience and medium used were significant predictors of search efficiency in the mathematics task, and accounted for 15% and 5% of the estimated variance respectively.

The multivariate regression analysis (reduced model) excluding those subjects who did not use keywords when provided (Table 6) suggested that the field dependence main effect was significant at the 0.05 confidence level in the mathematics task, and accounted for 9% of the estimated variance. The expected treatment main effect and field dependence by treatment interaction could not be supported at the 0.05 confidence level in either task. The covariate computing experience was a significant predictor of search efficiency in the mathematics task and accounted for nearly 22% of the estimated variance.

Insert Table 6 about here

These results indicated that an increase in GEFT score significantly predicted a greater number of relevant selections per minute in the mathematics task only when those subjects who used keywords when provided were included in the analysis. Further, field dependence and computing experience together accounted for nearly one third of the estimated variance in the mathematics task.

Number of Search Requests

The multivariate regression analysis including those subjects who did not use keywords when provided suggested that none of these predictions could be supported at the 0.05 confidence level in both tasks.

The multivariate regression analysis excluding those subjects who did not use keywords when provided confirmed that none of the predictions could be supported at the 0.05 confidence level (Table 7). The results, however, do suggest that treatment accounted for approximately 7% and 6% of the estimated variance for this dependent measure in the mathematics and biology tasks respectively. The results also confirm that the covariate computing experience significantly predicts the number of requests made in the biology task and that it accounted for 7% of the estimated variance.

Insert Table 7 about here

These results therefore indicated the actual use of keywords increased the number of requests made when searching the database.

Complexity of Search Strategy

The multivariate regression analysis including those subjects who did not use keywords when provided suggested only the field dependence in the mathematics task ($B = 0.046$, $F = 9.080$ [4, 67], $p < .05$) could be supported at the 0.05 level of confidence and accounted for approximately 17% of the observed variance ($\Delta R^2 = .172$, $F = 14.550$ [1, 70], $p < .001$) in the reduced model. Field dependence in the biology task accounted for nearly 9% of the variance of this dependent measure ($\Delta R^2 = .089$, $F = 8.258$ [2, 70], $p < .05$). The expected treatment main effect and the field dependence by treatment interaction were not found. The covariate computing experience was a significant predictor for this dependent measure in both tasks (mathematics task: $B = 0.110$, $F = 10.382$ [4, 67], $p < .05$; biology task: $B = 0.140$, $F = 16.330$ [4, 68], $p < .001$), and accounted for a further 11% of the observed variance in the mathematics task ($\Delta R^2 = .112$, $F = 10.809$ [2, 69], $p < .05$) and 16% in the biology task ($\Delta R^2 = .160$, $F = 13.495$ [1, 71], $p < .001$).

The multivariate regression analysis excluding those subjects who did not use keywords when provided (Table 8) confirmed that field dependence significantly predicted the proportion of multiple requests made in the mathematics task. Further, field dependence accounted for some 19% of estimated variance in the mathematics task and approximately 8% in the biology task. These results further confirmed that the covariate computing experience significantly predicted performance in both tasks on this dependent measure (mathematics task: $B = 0.012$, $F = 7.112$ [4, 52], $p < .05$; biology task: $B = 0.132$, $F = 12.972$ [4, 61], $p < .05$) and that it accounted for significant amounts of the estimated variance (mathematics task: $\Delta R^2 = .109$; biology task: $\Delta R^2 = .140$). The interaction term approached signifícnce ($p = .06$) for both tasks. The direction of this interaction confirmed the hypothesised effect.

Insert Table 8 about here

These results therefore indicated that an increase in GEFT score significantly predicted an increase in the proportion of multiple requests made in the mathematics task.

Search Profiles

It was predicted that search profile adopted would be significantly related to the provision of keywords (treatment), field dependence, and the field dependence by treatment interaction.

The search profiles of each subject were reconstructed by coding the search function in use at two minute intervals. For the purposes of this analysis, the functions coded were "call", "list", "search" (keyword or abstract), and "multiple search". Also as previously described, each subject was grouped according to similarity of profile using a hierarchical grouping technique. Discriminant analysis was used to estimate the predictive power of the treatment, field dependence, and the field dependence by treatment interaction on search profile group membership.

Mathematics Task. Figures 3 - 5 present the search profiles of groups identified as similar in the mathematics task. In group 1 (Figure 3) the dominant pattern was steady decline in the proportion who requested a "search" over the first twenty eight minutes, which was mirrored by a corresponding increase in the proportion who were calling programs. This pattern was slightly interrupted between twelve and eighteen minutes, when there was a slight increase in the proportion who were searching and a plateau in the proportion calling, indicating some reevaluation of programs at this time. Further reevaluation occurred between thirty six and forty eight minutes for some subjects. The remaining search functions, "list", "name", and "multiple search", were used by a small proportion of subjects in this group; about 16% were using the "name" function at the two minute interval, with a decreased proportion continuing to use this function for the first thirty minutes. About 11% were using the "multiple search" function after two minutes and its use continued somewhat sporadically for the first thirty minutes. The "list" function was used intermittently by a small proportion of subjects over the first thirty minutes. Overall, this pattern indicated that apart from some late reevaluation, most subjects in this group searched the database in the first sixteen minutes and then concentrated upon calling programs.

Insert Figure 3 about here

Group 2 in the mathematics task (Figure 4) demonstrated markedly different search profiles to group 1. A higher proportion were searching after two minutes. Over the first twenty minutes there was again a steady decline in the proportion of subjects searching, and a corresponding increase in the proportion calling. This pattern was also interrupted by a small increase in the proportion searching and a plateau in the proportion calling at about eight minutes. However, while there was a greater proportion searching than calling between twenty and forty minutes, the pattern suggested most subjects adopted a continued call-search-call pattern. This pattern continued between forty and sixty minutes, but with fewer subjects swapping between the "call" and "search" functions. The "list" function was used by up to 22% of this group for the first thirty six minutes, and again in the last ten minutes. The "name" function was used intermittently throughout this session, and peaked at forty eight minutes for 22% of the group. "Multiple search" was used by about 8% of the group in the first twelve minutes, and by 22% between twenty four and twenty eight minutes. Overall, the results indicated that similar to group 1, most subjects in this group were concerned with searching in the first sixteen minutes. However, most subjects then adopted a call-search-call pattern which, for some subjects, lasted until the conclusion of searching.

Insert Figure 4 about here

The dominant feature of the profiles of group 3 (Figure 5) was the extended call-search-call pattern which, for most subjects, lasted for the first twenty five minutes, and continued for some subjects until approximately fifty minutes had elapsed. The "list" function was used sporadically for the first forty minutes. The "name" function was used continually for the first twelve minutes only. The "multiple search" function was used intermittently for the first twenty four minutes by a small proportion of this group. Overall, these results indicated continued early use of both "search" and "call" functions, but then a rapid cessation of searching in favour of calling after about twenty four minutes.

Insert Figure 5 about here

In summary, these results indicated that subjects adopted very different search strategies when seeking information for the mathematics task. These strategies ranged from an early search then call pattern (group 1), early call then search but continued reevaluation of the information (group 2), and extended call-search-call (group 3). The "name", "list" and "multiple search" functions were used by only a small proportion of members of all groups. It was deduced that only the members of group 1 adopted a conceptual-type search strategy, as they tended to first search the database and then view the actual programs. Conversely, groups 1, 2 and 3 adopted search strategies that were characterised by more immediate calling of programs found.

Biology Task. As with the mathematics task the search profiles of groups were identified as similar in the biology task. The dominant pattern in group 1 was the rapid decline in the proportion of subjects searching and a corresponding increase in the proportion calling over the first sixteen minutes.

Group 2 in the biology task again demonstrated markedly different search profiles to group 1. While the proportion searching was always greatest, many subjects oscillated between calling and searching during the first thirty eight minutes.

Most subjects in group 3 of the biology task adopted a continued searching pattern for the first twenty minutes, with only a small proportion calling during the early stages of this period. The "multiple search" function was used continuously in this time by between 14% and 22% of the group.

In summary, these results confirmed the earlier observation that subjects adopted very different search strategies when seeking information from the database used in this study. In the biology task the strategies adopted ranged from an early search then call pattern but with continued reevaluation (group 1), continued search and call (group 2) and concentrated early search then call (group 3). Also in keeping with the previous discussion was the fact that only a small proportion of subjects in the biology task used the "list", "name" and "multiple search" functions available to them. It was deduced that only the members of group 3 adopted a conceptual-type search, as they tended to first search the database and then view the programs found. Conversely, groups 1 and 2 adopted search strategies that were characterised by more immediate calling of programs found.

DISCUSSION

When those subjects who did not use keywords when provided were excluded from the analysis, subjects who actually used keywords took more search time in the mathematics task. This result suggested that rather than reducing the search time as predicted, the actual use of keywords enabled subjects to adopt a more comprehensive search of the database than without keywords. This finding therefore suggests that the mere provision of an on-line search-aid such as keywords is not in itself a sufficient guide to study the manner in which people interrogate a computerised information system. Instead, detailed records should be kept of the actual search functions used, and in this way designers may be able to better match such systems to the actual information processing strategies of users. The use of keywords did appear to facilitate a higher number of search requests in both tasks, and accounted for significant amounts of the observed variance of the dependent measures. These trends are consistent with results reported in previous studies.

A number of points need to be made concerning the keywords used in this study. First, the nature of the keyword descriptors used in each database entry was not known to subjects prior to testing. Several subjects reported that the provision of these descriptors would have helped them to understand the nature of the database, and thus expedite search request formulation. It appears that to use the keywords provided effectively, subjects first had to establish the keyword structure. This possibly explains the observation that when completing the "with keywords" task some subjects did not request a keyword search.

Second, reviewers of aptitude-treatment interaction research (eg. Berliner & Cahen, 1973; Cronbach & Snow, 1977; Tobias, 1976 & 1977) have noted that the treatments in many studies have varied only in minor details and thus fail to rely upon different types of information processing. While the literature reviewed suggested that the provision of a search-aid such as keywords would facilitate differences in mental processing, the results suggest this may not have been the case.

Field Dependence

While field dependence did not significantly predict either search and selection performance or strategy on most dependent measures used in this study, an increase in GEFT score did predict reduced search time, increased number of relevant selections per minute and increased complexity of subjects' search strategy in the mathematics task. While these results suggested there were some task related differences in performance measures used in this study (which were supported by subject interviews), they also indicated that field independent subjects were better able to access the database.

There are several possible reasons why the expected field dependence effect was not observed in more of the dependent measures. First, while the Group Embedded Figures Test was administered strictly according to the instructions provided by Witkin et al (1971), a negatively skewed distribution was observed. Similar results were reported by Benbasat and Dexter (1979 & 1982) and Lusk (1979). Perhaps the time limit for this test should be reduced to achieve a more normal distribution around the mean. Another measure of field dependence (Hidden Figures Test; French, Ekstrom & Price, 1976) was administered _post hoc_ to sixty seven of the seventy seven subjects of this study. Results of this testing suggested a more normal distribution ($\bar{X}$ = 19.448, SD = 7.548) than the Group Embedded Figures Test for the same sample. Univariate regression analyses using the HFT on the dependent measures of this study suggested an increased HFT score significantly predicted an increase in the number of relevant selections and the number of relevant selections per minute in the mathematics task, and an increase in the proportion of multiple requests in both tasks. Therefore, the application of other measures of field dependence, such as the Hidden Figures Test, to information acquisition studies might reveal a more comprehensive view of this individual difference variable.

Second, previous studies using field dependence to predict information acquisition performance and behaviour have classified subjects as either field dependent or field independent. The most common basis for categorisation is GEFT scores 0 - 13 as field dependent and 14 - 18 as field independent. Such a classification scheme has the danger of allowing within group variance to be greater than between group variance. In the present study field dependence was entered into the regression models as a continuous variable, thus departing from the previously reported studies. Perhaps the less significant effect of field dependence is explained by this methodological difference.

These results do suggest, however, that field dependence is worthy of further consideration as an individual difference measure in the context of the study of information processing behaviour of novice computer users.

Interaction Effects

As previously noted, the only significant first order field dependence by use of keywords interaction observed in this study was that for search time in the mathematics task. This result indicated that an increase in GEFT score facilitated the use of less search time for subjects actually using keywords and an increase in search time for those not using keywords.

This observed interaction suggested that when using keywords field dependent subjects were able to adopt a more comprehensive search strategy than when not using keywords, which is supported by the fact that field dependents made less relevant selections per minute in the same task. While the same significant interaction was not observed in the biology task, it is suggested that with regard to search time, field dependence and the provision of keywords should be considered concurrently in the design of computerised information systems.

Search Profiles

Previous discussion concerning subjects' search profiles has shown that in this study the provision of keywords, field dependence or the first order field dependence by treatment interaction did not significantly predict similarity of profile.

The results did, however, indicate that subjects adopted very different search strategies when accessing information from the database used in this study. The strategies ranged from a comprehensive search prior to calling to the immediate calling of programs found.

Post hoc comparisons between the search profiles adopted by all subjects in both tasks revealed some similarities. In general terms there was a steady decline in the proportion searching which was matched by an increase in the proportion calling, with only a small proportion who used the "list", "name" and "multiple search" functions. In the biology task, however, the cross over of the proportion calling and searching occurred at twenty two minutes; some five minutes later than the mathematics task. Further, there was more evidence of oscillation between searching and calling in the early stages of the biology task.

These results concur with the suggestion that the design of database query programs should be kept simple for novice users (Zloof, 1978), a point supported by the fact an increase in computing experience score significantly predicted the proportion of multiple requests in both tasks. Apparently novice users did not use the variety of possible means to interrogate the database, and only the more experienced computer users tended to use the "multiple search" function. The results also provide evidence to support the user taxonomy suggested by Schneider (1982) in that if a "multiple search" is assumed to be an indication of chunk size, more experienced computer users employed larger chunks when interrogating the database used in this study. While accepting the danger of over-generalising this finding, the extent to which computing experience influences the degree to which users process information in a "controlled" or "automatic" manner (Shiffrin & Schneider, 1977) should be the subject of future research.

Computing Experience

The results from this study suggested that both database interrogation performance and strategy were influenced by computing experience. This covariate significantly predicted the number of relevant selections, the number of relevant selections per minute in the mathematics task, the number of requests made in the biology task, and the proportion of multiple requests in both tasks. In this study the computing experience measure was taken from a self report instrument which required subjects to indicate their level of computing experience on a scale ranging from "little or none" to "regular user". Even though the database query program was designed with novice computer users in mind, and all subjects received a forty five minute training session and completed two practice examples, those subjects who reported a higher level of computing experience were generally more successful at the database interrogation tasks. It is suggested that more computer experienced subjects, at least when compared to novice users, were less concerned with terminal operation and details of the query language, and were more familiar with the nature of CAL materials. It was therefore summised more experienced users were able to process information relating to the tasks in a manner akin to automatic processing, whereas novice users adopted a more controlled processing approach.

This finding may be of importance to the designers of computer information systems for several reasons. First, if such systems are to approach their full potential as information storage and retrieval tools they must be easily operable by novice, irregular and less interested users as well as experienced operators. This finding further concurs with the recommendation made by Zloof (1978) for the design of user-friendly data manipulation languages for non-programmers. Zloof suggested that instructions and operations should be kept very simple for novice users - apparently more simple than those used in this study. Future studies might specifically examine Zloof's criteria in the context of information acquisition by novice computer users.

Second, if level of computing experience does influence the information processing strategies adopted when interacting with a computerised information system in the manner suggested by this study, then educators should perhaps give consideration to the nature of introductory computer courses. Instead of teaching computer programming techniques, there may be value in the provision of computer awareness courses which focus upon interactive computing experience with a variety of existing information systems and educational materials.

In either case, the development of more comprehensive measures of computing experience based on the user taxonomy suggested by Schneider (1982) may be a useful instrument to guide further evaluation of this finding.

Content Area Background

Those subjects who indicated more experience in mathematics and biology made a higher number of relevant selections in both tasks. This finding indicates that the tasks set for this study may have been too specific for the sample tested. Subject interviews supported this proposition in the case of the biology task. It also confirms the view of Sage (1981) that the familiarity of searchers with the content being searched is an important consideration for information system design.

Within the structure of this study it is further suggested that familiarity with the content of the tasks enabled subjects to concentrate less upon the suitability of materials found and direct more attention to the operations of the information system. As in the case of computing experience discussed above, it was summised familiarity with the content area facilitated automatic as opposed to controlled information processing. Whilst highly speculative, it is recommended this conclusion be investigated by future research.

Keyboard Expertise

As defined by this study, keyboard expertise did not significantly predict database interrogation performance or strategy. This was also a surprising result given that subjects varied markedly in their observed keyboard skills, and the fact that many subjects were quite literally "hunting and pecking" their way around the keyboards. Given this observation, and since there has been considerable recent market attention paid to "user friendly" keyboards (eg. Apple Lisa computers), it is suggested further research might examine more fully the effects of this demographic variable in the context of novice computer users interrogating information systems.

Relationship of Results to Major Questions

At the outset of the study six major questions were posed.

1. Does the provision of keywords as an on-line search-aid facilitate search and selection performance from a computerised information system?

From the results of this study this question was tentatively answered in the negative. Despite subjects reporting the "with keywords" task to be easier, their provision as a search-aid did not affect database interrogation performance.

Further analysis revealed, however, that those subects who actually used keywords when provided took significantly more search time in one of the tasks. Therefore, it was concluded that the actual use of keywords may influence comprehensiveness of the search adopted but does not influence either the number of relevant selections or search efficiency.

Possible reasons which may explain the lack of effect of the provision of keywords in more dependent measures have been previously discussed. In summary, it is possible that the lack of prior knowledge of how keywords were derived, unfamiliarity with computers and accessing specific parts of the data entry, and the apparent small difference between treatments may have contributed to this result.

2. Does field dependence predict search and selection performance from a computerised information system?

The expected better performance of field independent subjects was observed in terms of search time, search efficiency and complexity of search strategy in one of the tasks. These results suggest field dependence is worthy of further study in the context of information search and selection performance. In particular, search time and efficiency of users might be affected by their ability to disembed complex information from its background.

Several reasons have been suggested which may explain why some results were at variance to the results of previous research dealing with field dependence and information acquisition; the most important being methodological. Studies by Benbasat and Dexter (1979 & 1982), Lusk (1979) and Bariff and Lusk (1977) have used field dependence as a median split categorical variable. This study assumed field dependence to be a continuous variable, therefore possibly reducing its statistical effect as a predictor but avoiding the methodological dangers associated with median split analyses.

A further reason for the observed low predictive power of field dependence may have been associated with the measure used in this study. It was noted that results observed from the Group Embedded Figures Test were not normally distributed around the mean, and it was suggested that the time limit of this test might be lowered in order to increase its reliability. Post hoc analyses using the Hidden Figures Test as a measure of field dependence improved the predictive ability of this measure.

3. Do subjects with different field dependence scores perform differently when interrogating a computerised information system with and without the search-aid of keywords?

The results of this study suggest that the answer to this question is a tentative yes. While the field dependence by provision of keywords interaction did not approach significance on the number of relevant selections and search efficiency, the analyses suggested that the field dependence by actual use of keywords interaction significantly predicted the amount of search time taken in one task and accounted for a significant amount of variance in the other. The observed interaction suggested that the use of keywords facilitated in field dependents the ability to adopt a more comprehensive search than without keywords. While this interaction was not significant in the other task, it could be that field dependence and use of search-aids such as keywords should be considered concurrently by designers of computerised information systems.

4. Does the provision of keywords as an on-line search-aid influence subjects' search and selection strategy when interrogating a computerised information system?

The results of this study indicate that the answer to this question is no. The provision or actual use of keywords did not significantly predict performance in terms of strategy as interpreted in this study.

5. Does field dependence predict subjects' search strategy when interrogating a computerised information system?

The answer to this question is conditionally no. From the results of this study, it was apparent that in one task field independent subjects made more relevant selections than field dependent subjects, but this observation was not confirmed in the other task. Further, field dependence did not predict the number of requests made or similarity of search profile in either task.

Possible reasons for the lack of a differential effect for field dependence in more of the dependent measures used in this study have been discussed in Question 2.

6. Do subjects with different field dependence scores adopt different search strategies when interrogating a computerised information system with and without the search-aid of keywords?

The answer to this question is no. The results of this study indicated that none of the field dependence by provision/use of keywords interaction reached significance in any strategy dependent measures.

Conclusions

It would be invalid to generalise the results of this study to all information acquisition situations. The experimental design used here dealt with a particular class of novice computer users who were searching for a concentrated period of time. The type of database and query language used in this study would only be typical of local situations and not large commercial or public information systems. Within the framework of these limitations the following conclusions may be drawn.

1. The use of keywords as an on-line search aid to novice computer users facilitates a longer search time and more comprehensive search strategy in one of the tasks in this study.
2. Field dependence predicts database interrogation performance in terms of search time, efficiency of searching and complexity of search strategy adopted for novice computer users. In one of the two tasks of this study, field independent persons took less search time, achieved more relevant selections per minute, and adopted a more complex search strategy than field dependent persons.
3. The use of keywords generally did not interact with field dependence to influence database interrogation selection performance or strategy, but where it did field dependent persons adopted a longer and more comprehensive search than those not using keywords.
4. Novice computer users find interrogation of on-line information systems difficult and approach such tasks with a high level of anxiety.
5. The search profiles of computer users vary from an extended search pattern before detailed examination of information found to immediate checking of relevant information once discovered.
6. Most computer naive people employ only the simple functions of a database query system despite training on the available range of functions.
7. The level of users' computing experience influences both performance and strategy adopted when interrogating an on-line information system. Computer naive people adopt a simple search strategy, whereas those even minimally more experienced with computers use the more complex search facilities available.

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Table 1

Means and Standard Deviations
of Independent Measures by Treatment

Treatment Group	Cases	GEFT	C'puting Exp.	K'board Exp.	Maths B'ground	Biology B'ground
1 {(MKW) (BKW)	38	14.24 (3.91)	1.89 (1.14)	2.19 (1.12)	2.92 (1.23)	2.25 (0.97)
2 {(MKW) (BKW)	39	13.49 (3.43)	1.79 (1.22)	1.97 (0.93)	2.79 (1.02)	2.10 (0.99)
Total	77	N=77 13.86 (3.67)	N=75 1.84 (1.18)	N=75 2.08 (1.02)	N=74 2.85 (1.12)	N=75 2.17 (0.98)

Table 2

Results of all Dependent Measures by Provision of Keywords

	Keywords			Without Keywords			Difference		Overall	
	N	$\bar{X}$	SD	N	$\bar{X}$	SD	t	p	$\bar{X}$	SD
Mathematics Task										
Relevant Selections	37	2.24	1.34	38	2.21	1.65	0.09	.925	2.23	1.49
Search Time	37	25.35	15.16	37	25.65	19.65	−0.07	.942	25.50	17.43
Relevant Selections /Minute	36	0.14	0.18	37	0.13	0.14	0.42	.679	0.13	0.16
Number of Requests	38	4.71	2.90	37	3.78	3.05	1.35	.182	4.25	2.99
Proportion of Multiple Requests	37	0.35	0.40	37	0.26	0.38	0.99	.327	0.31	0.39
Biology Task										
Relevant Selections	38	2.13	1.36	36	2.53	1.18	−1.33	.186	2.32	1.28
Search Time	38	36.00	17.68	37	36.70	23.23	−0.15	.883	36.35	20.47
Relevant Selections /Minute	38	0.07	0.06	36	0.10	0.08	−1.42	.161	0.08	0.07
Number of Requests	37	7.57	4.59	37	5.86	4.08	1.69	.096	6.72	4.40
Proportion of Multiple Requests	38	0.38	0.40	36	0.29	0.40	1.00	.319	0.34	0.40

Table 3

Results of all Dependent Measures by Actual Use of Keywords

	Keywords			Without Keywords			Difference	
	N	$\bar{X}$	SD	N	$\bar{X}$	SD	t	p
Mathematics Task								
Relevant Selections	22	2.50	1.44	38	2.21	1.65	0.73	.470
Search Time	22	27.77	17.58	37	25.65	19.65	0.42	.678
Relevant Selections /Minute	21	0.16	0.22	37	0.13	0.14	0.76	.450
Number of Requests	23	5.48	3.22	37	3.78	3.05	2.05	.045*
Proportion of Multiple Requests	22	0.56	0.40	37	0.26	0.38	2.88	.006*
Biology Task								
Relevant Selections	31	2.39	1.23	36	2.53	1.18	- 0.48	.635
Search Time	31	36.26	17.84	37	36.70	23.23	- 0.09	.931
Relevant Selections /Minute	31	0.08	0.06	36	0.10	0.08	- 0.85	.397
Number of Requests	37	8.03	4.83	37	5.86	4.08	1.99	.049*
Proportion of Multiple Requests	31	0.42	0.40	36	0.29	0.40	1.34	.184

*$p<0.05$

Table 4

Reduced Multivariate Regression Model for Number of Relevant Selections (Excluding Non Keyword Users)

	B	F(df)	p	ΔR^2	ΔF(df)	p
Mathematics Task		(4, 54)				
Constant	0.216	0.016	.898			
Treatment	- 0.132	0.005	.945	.000	0.005 (4, 54)	.945
Field Dependence	0.101	0.932	.339	.059	3.851 (2, 56)	.055
FD x Treatment	0.010	0.007	.935	.000	0.004 (3, 55)	.949
Computing Experience	0.352	5.058	.029*	.080	4.960 (1, 57)	.030*
Total	R^2 = .139; F = 2.187(4, 54); p = .083					
Biology Task		(3, 63)				
Constant	1.854	4.490	.038*			
Treatment	0.174	0.022	.882	.002	0.156 (2, 64)	.694
Field Dependence	0.035	0.449	.505	.014	0.937 (1, 65)	.337
FD x Treatment	0.004	0.003	.960	.000	0.003 (3, 63)	.960
Total	R^2 = .017; F = 0.355(3, 63); p = .785					

*p<0.05

Table 5

Reduced Multivariate Regression Model for Search Time (Excluding Non Keyword Users)

	B	F(df)	p	ΔR^2	ΔF(df)	p
Mathematics Task		(3, 55)				
Constant	93.178	22.304	.000*			
Treatment	− 75.089	10.683	.002*	.009	0.507 (2, 56)	.479
Field Dependence	− 4.298	11.396	.001*	.020	1.172 (1, 57)	.284
FD x Treatment	4.858	10.099	.002*	.151	10.099 (3, 55)	.002*
Total	R^2 = .180; F = 4.013(3, 55); p = .012*					
Biology Task		(3, 64)				
Constant	56.724	14.930	.000*			
Treatment	0.038	0.000	.999	.000	0.000 (3, 64)	.998
Field Dependence	− 1.409	2.580	.113	.068	4.719 (1, 66)	.033*
FD x Treatment	− 0.097	0.005	.944	.001	0.081 (2, 65)	.776
Total	R^2 = .068; F = 1.554(3, 64); p = .209					

*$p<0.05$

Table 6

Reduced Multivariate Regression Model for Number of Relevant Selections per Minute (Excluding Non Keyword Users)

	B	F(df)	p	ΔR^2	ΔF(df)	p
<u>Mathematics Task</u>		(4, 52)				
Constant	- 0.356	4.302	.043*			
Treatment	0.199	1.041	.312	.002	0.146 (3, 53)	.704
Field Dependence	0.024	5.183	.027*	.091	7.234 (2, 54)	.009*
FD x Treatment	- 0.012	0.924	.341	.012	0.924 (4, 52)	.341
Computing Experience	0.069	18.882	.000*	.227	16.171 (1, 55)	.000*
<u>Total</u>	R^2 = .332; F = 6.468(4, 52); p = .000*					
<u>Biology Task</u>		(3, 63)				
Constant	0.019	0.149	.700			
Treatment	0.035	0.279	.600	.008	0.526 (2, 64)	.471
Field Dependence	0.003	0.895	.348	.039	2.619 (1, 65)	.110
FD x Treatment	0.002	0.126	.723	.002	0.126 (3, 63)	.723
<u>Total</u>	R^2 = .049; F = 1.070(3, 63); p = .368					

*$p<0.05$

Table 7

Reduced Multivariate Regression Model for Number of Requests (Excluding Non Keyword Users)

	B	F(df)	p	ΔR^2	ΔF(df)	p
<u>Mathematics</u> <u>Task</u>		(3,56)				
Constant	8.908	6.531	.013*			
Treatment	- 7.171	3.121	.083	.068	4.203 (1,58)	.045*
Field Dependence	- 0.224	0.988	.325	.016	0.988 (3,56)	.325
FD x Treatment	0.377	1.943	.169	.017	1.047 (2,57)	.311
<u>Total</u>	R^2 = .100; F = 2.080(3,56); p = .113					
<u>Biology</u> <u>Task</u>		(4,61)				
Constant	8.037	5.998	.017*			
Treatment	- 6.945	2.771	.101	.058	4.205 (2,63)	.044*
Field Dependence	0.201	1.153	.287	.016	1.153 (4,61)	.287
FD x Treatment	- 0.341	1.374	.246	.006	0.396 (3,62)	.531
Computing Experience	1.001	5.039	.028*	.068	4.683 (1,64)	.034*
<u>Total</u>	R^2 = .148; F = 2.652(4,61); p = .042*					

*$p<0.05$

Table 8

Reduced Multivariate Regression Model for Proportion of Multiple Requests (Excluding Non Keyword Users)

	B	F(df)	p	ΔR^2	ΔF(df)	p
Mathematics Task		(4, 52)				
Constant	- 0.519	1.589	.213			
Treatment	0.013	0.001	.977	.000	0.001 (4, 52)	.977
Field Dependence	0.057	4.959	.030*	.194	13.192 (1, 55)	.001*
FD x Treatment	- 0.013	0.187	.667	.046	3.695 (3, 53)	.060
Computing Experience	0.102	7.112	.010*	.109	8.428 (2, 54)	.005*
Total	R^2 = .348; F = 6.933(4, 52); p = .000*					
Biology Task		(4, 61)				
Constant	- 0.419	2.434	.124			
Treatment	0.144	0.176	.676	.002	0.176 (4, 61)	.676
Field Dependence	0.022	2.088	.154	.075	6.034 (2, 63)	.017*
FD x Treatment	0.021	0.800	.375	.044	3.684 (3, 62)	.060
Computing Experience	0.132	12.972	.001*	.140	10.438 (1, 64)	.002*
Total	R^2 = .262; F = 5.400(4, 61); p = .001*					

*$p<0.05$

	Mathematics Task	Biology Task
Group 1	KW FD O_1	$\overline{KW}$ FD O_3
Group 2	$\overline{KW}$ FD O_2	KW FD O_4

KW = Keywords
$\overline{KW}$ = Without keywords
FD = Field dependence
O_1 through O_4 = Observations

Figure 1: Experimental design

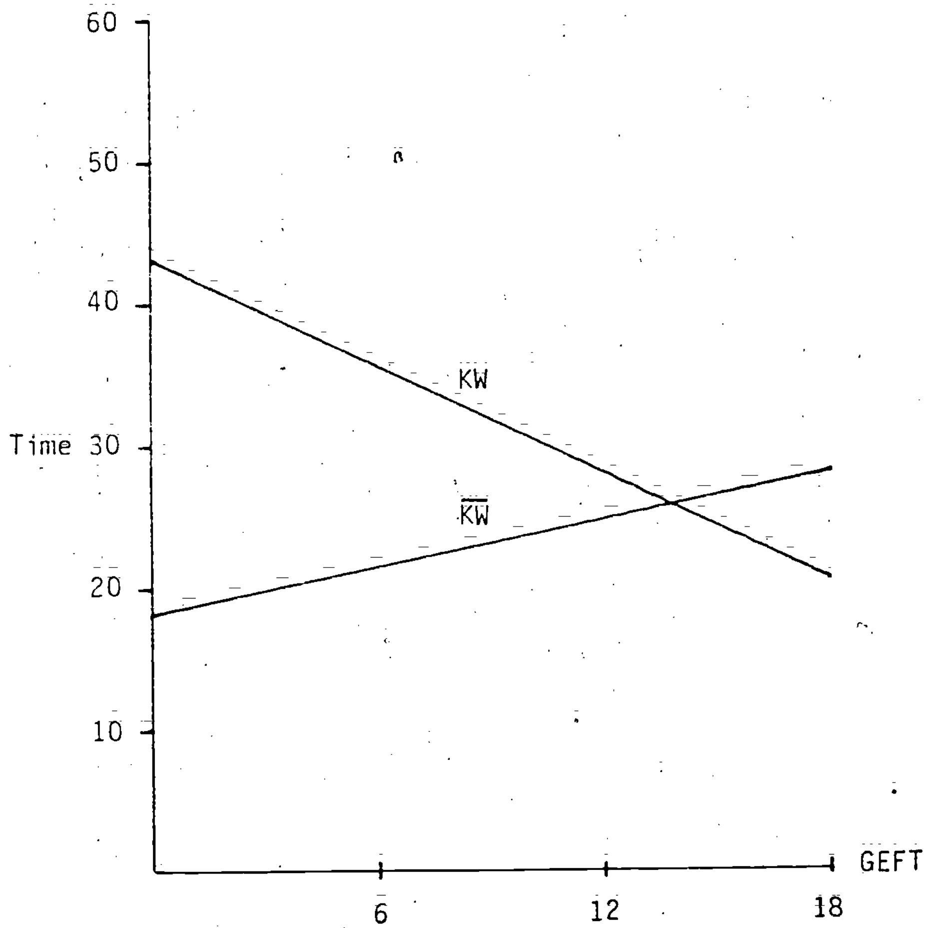

Figure 2: Plot of field dependence regression lines for treatment groups on search time (mathematics task)

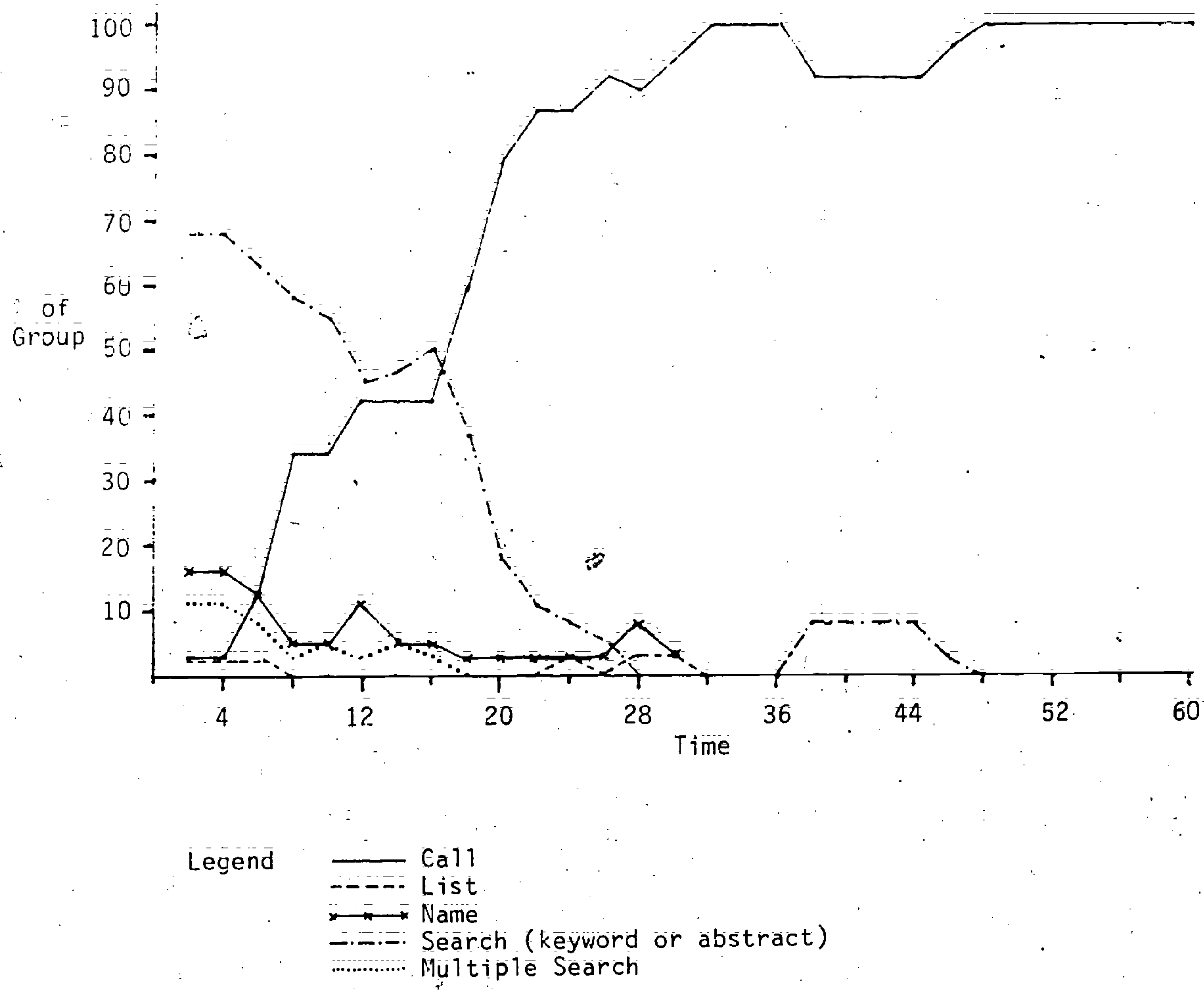

Figure 3: Search profiles, group 1: Mathematics task (n = 39)

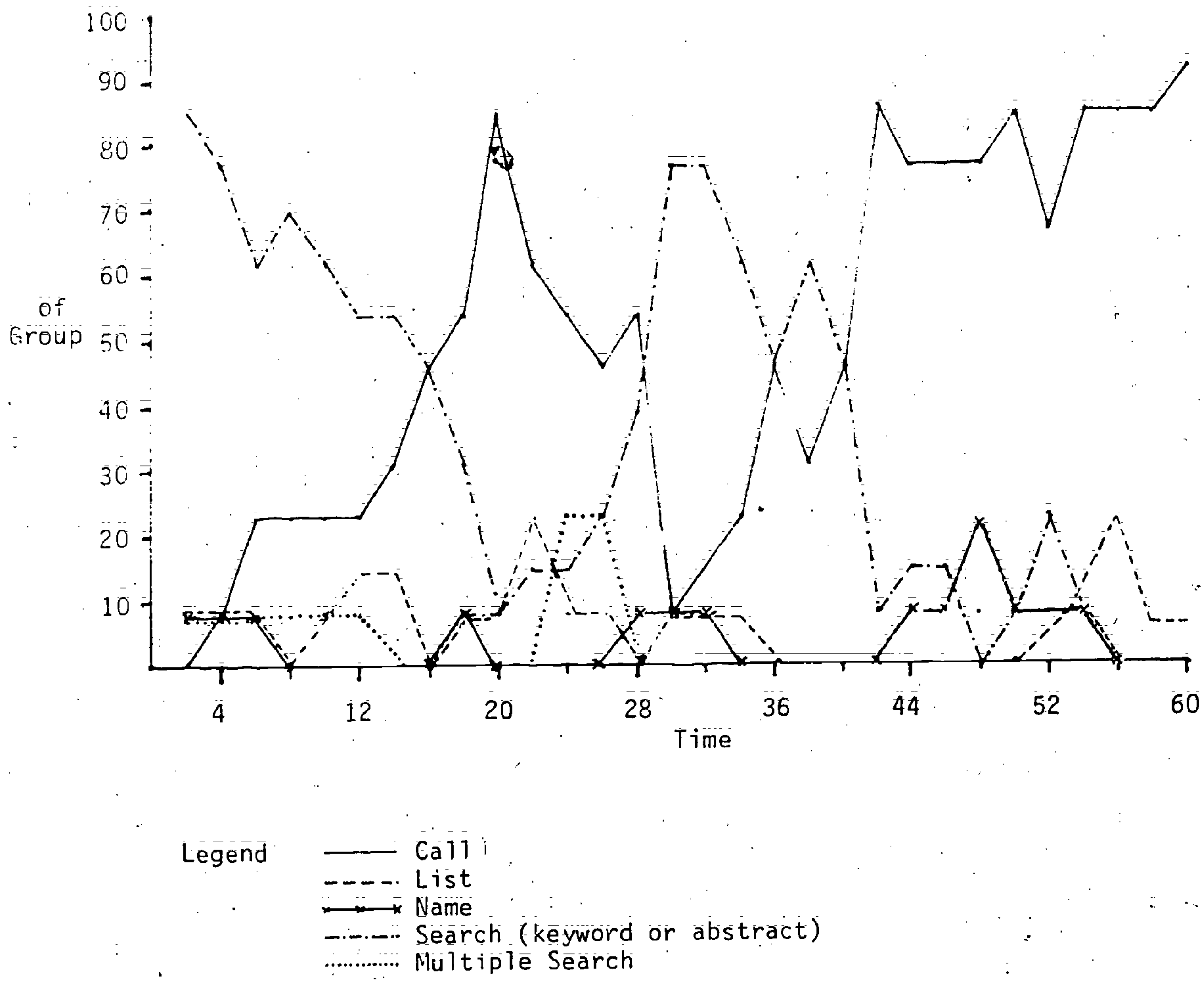

Figure 4: Search profiles, group 2: Mathematics task (n = 13)

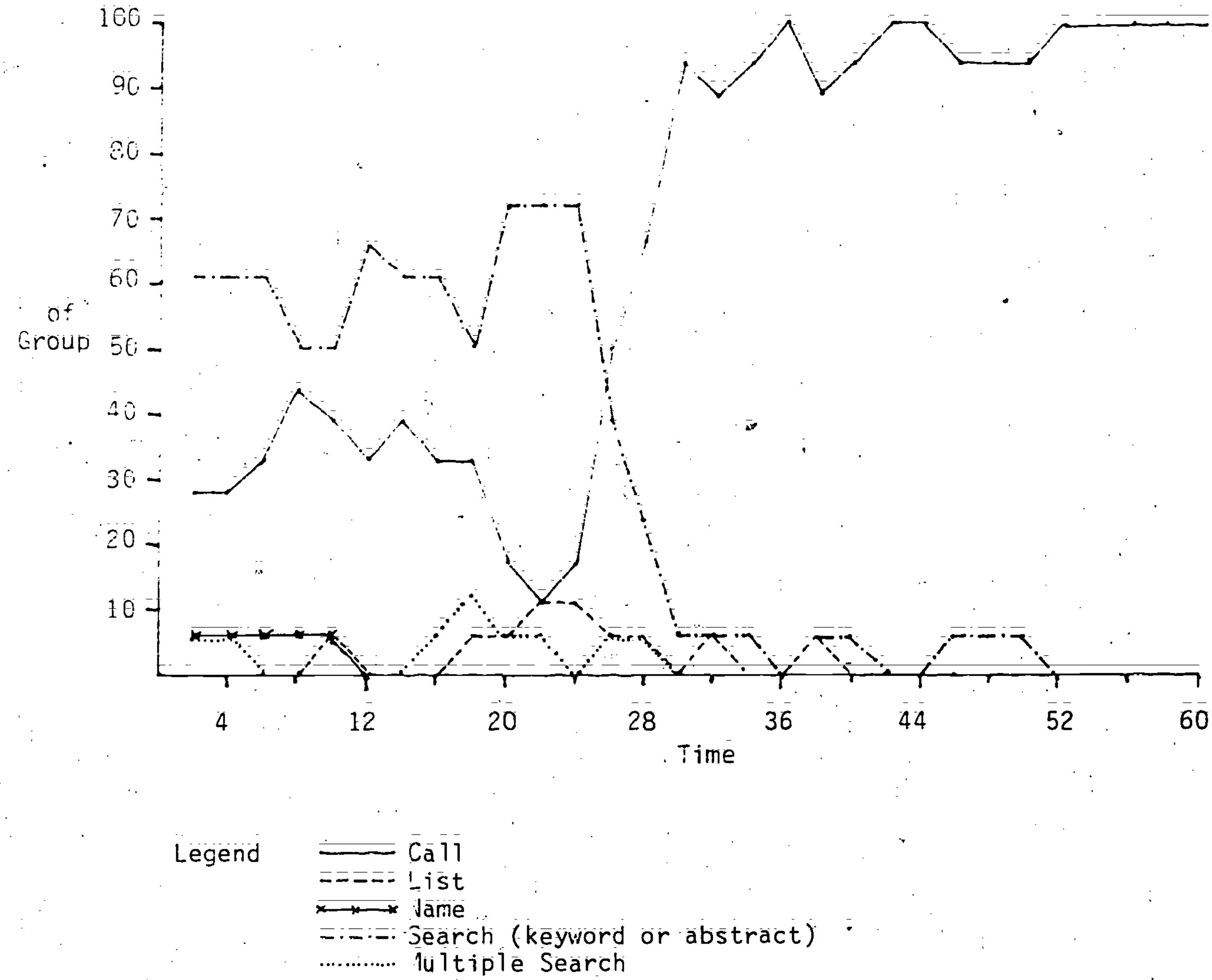

Figure 5: Search profiles, group 3: Mathematics task (n = 17)