Navigating Information Space

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Abstract

The issue of how users can navigate their way through large information spaces is one that is crucial to the ever expanding and interlinking of computer systems. There are many ways of dealing with the issue of navigation one of which is to provide different dialogue styles to suit individual capabilities. The performance of users was compared on a menu style interface to a database system, which minimised navigation and constrained the dialogue, and a command style interface, which allowed an open and flexible dialogue. The results showed that some users did perform better on the interface which minimised navigational issues, and some better on the more open interface; and that users' performance related to their levels of spatial ability and experience with using command style interfaces. The menu interface proved suitable for users with both a low spatial ability and low experience of using command style interfaces. The command interface proved suitable for all users with a high spatial ability, whatever their previous experience, and for users with a low spatial ability but high experience of using command style interfaces. The results of this small scale experiment have potentially important ramifications for designers of interfaces to large information spaces.

Acknowledgement

This work formed part of a project entitled 'Adaptive Systems and User Modelling Tools', funded by the National Physical Laboratory, Teddington, UK, under extra-mural research agreement 82-0486. Francis Jennings conducted the experiments and wrote much of an earlier version of this paper.

1. INTRODUCTION

The concept of an 'information space' is one that is becoming increasingly important in the current era of networked computers. Information spaces are manifested in such areas as multiple interacting databases where 'data mining' is a major issue. The same is true in large hypermedia systems such as the world wide web. Even traditional information retrieval systems demonstrate this complexity.

Such systems often have a large end-user population. This is particularly true of systems such as public information systems, but is also apparent in commercial information retrieval systems where the same database may be used by sales representatives, junior and senior managers, clerks and receptionists. With a large user population there can be a considerable diversity amongst the users of a system in terms of their education and training, their previous experiences, skills and their requirements. For a diverse user group, it is questionable whether a single interface design could be produced which would suit the individual capabilities and requirements of all users. The situation is exacerbated by the size and complexity of the information space itself.

Although people can adapt to some extent to an interface design which is not ideal for them, there are some capabilities of users which they cannot easily change, such as certain

personality and cognitive characteristics (van der Veer, 1990). Of course there are many possible solutions to the problems of users navigating their way through large information spaces. Designers can utilise a range of techniques to help users find their way. Maps and guides offer one solution. Signposts and providing useful 'landmarks' offer another. Paying attention to general interface design presents another. However, all these make certain demands on their users. These demands, in particular, expect users to have certain characteristics - to be able to follow signs, to recognise landmarks, and so on. Indeed, if an information retrieval system is to suit all its users, it is likely that different interfaces will be necessary for different users.

The study reported in this paper investigated whether different users of information retrieval systems require interfaces with different dialogue styles to suit their individual capabilities. Dialogue style refers to the methods which are employed by users to specify commands to the computer. For example in one style the user types in commands to communicate with the system, in another users select items from menus, in a third they may use a mouse to select pictures. Different dialogue styles place different demands on their users (Schneiderman, 1987; Thimbleby, 1991). For example, some styles require the user to drive the dialogue and remember complex syntax, others guide the user and provide all the options for input, others require the user to interpret icons. It is likely that these demands will differentially suit users according to their capabilities.

Dialogue style was chosen as the area of interface design to examine in this study as many assumptions have been made about which dialogue styles are suitable for which users of information retrieval systems, but little research has been carried out to confirm or question these assumptions. Everest (1986) suggests that menu style interfaces are suitable for novice users, natural language (NL) interfaces are more appropriate for casual users and command language interfaces would suit frequent users. Codd (1974) argues that casual users cannot be expected to formulate unambiguously their queries in natural language. They require a more sophisticated form of natural language interface which assists in clarifying the meaning of a query. Both Reisner (1977) and Ehrenreich (1981) have examined the usability of various database query languages though they offer few concrete conclusions as to which is more suitable for which users. Davis (1989) looked at two types of interface to databases, but concentrated on general characteristics rather than the cognitive features which interested us.

The information retrieval systems which are currently available do have different dialogue styles, for example many systems are command based and many are menu based. Other systems provide WIMP interfaces and command keys. This suggests that there is a need for different dialogue styles to suit the users of information retrieval systems, but the link between the dialogue styles and the users for which they are suitable is not clear. In short, we do not know enough about the characteristics of users which effect their performance or enjoyment when using information retrieval systems. Nor do we know enough about the demands which different dialogue styles make of their users.

In order to begin to rectify this situation, a study of information retrieval use was undertaken. Our primary interest lay in examining the relationships between long-term and relatively stable user characteristics and the use of information retrieval system interfaces after the initial learning stage. In the preliminary experiment (reported fully in Jennings, Benyon and Murray, 1991) five cognitive preferences and abilities were examined in relation to five dialogue styles. Section 2 reviews this work. In the second experiment (Section 3) we concentrated on the

most significant of these cognitive abilities (spatial ability) in relation to two dialogue styles (a command interface and a menu interface) which captured the essential characteristics of the five examined in the first experiment. Section 4 presents a discussion of these studies.

2. PRELIMINARY EXPERIMENT

A preliminary experiment (Jennings, Benyon and Murray, 1991) was carried out to investigate how a number of characteristics of users related to their performance on an information retrieval system with a number of different dialogue styles. The information retrieval system developed for this experiment supported the single task of obtaining lists of items available from a mail-order shopping catalogue. Users had to specify the type of item they were interested in and values for three of its attributes. The users were required to query the database and obtain information such as:

> How many types of women's t-shirts are available, which cost less than £15, are navy in colour and are U.K. size 14-16?
> or
> Are there any carpets available, which cost less than £10 per yard, are brown in colour and 13 feet in width?

User Characteristics

Five cognitive and personality characteristics were considered, which, from previous research into the relationship between users' performance on computer systems and individual characteristics, looked likely to have relevance to users' success with different interface dialogue styles. (See Egan (1988) for an introduction to previous work in this area.)
The characteristics selected were (i) spatial and (ii) verbal ability, shown by Vicente, Hayes and Williges (1987) to relate to users' performance on a computer hierarchical file searching task (iii) field dependency, suggested by Fowler and Murray (1988) to relate to users' ability to cope with an open and flexible dialogue (iv) short term memory capacity, suggested by Benyon, Murray and Milan (1987) to relate to performance on fast and slow computer dialogues and (v) logical versus intuitive thought, shown by Garceau, Oral and Rahn (1988) to relate to preference for graphical or tabular presentations of data. Users' previous experience with using particular interface dialogue styles was also considered. The subjects were given psychological tests (NFER-NELSON, Myers-Briggs, Saville and Holdsworth) to determine their positions on the selected cognitive and personality variables and were allocated to a 'high' or 'low' group according to these scores. In addition, subjects were given a questionnaire asking them to rate their experience of using interfaces similar to each of the five types of test system interfaces. Experience could be rated as none, some or a lot.

Interface Styles

Five interface dialogue styles were considered, which represent commonly available styles of interface: a command language interface (cf. MS-DOS), a question and answer interface (cf. many commercial data entry systems), a menu interface (cf. many Apple Macintosh applications), a button interface (cf. many Hypercard applications) and an iconic interface (cf. MacPaint and MacDraw on the Apple Macintosh).

Having five representative interfaces provided a number of benefits. First, user characteristics could be looked for which affected users' use of many interface styles, not just one. Second, performance differences due to the *task* could be distinguished from performance differences due to the *interface*. If a particular user characteristic had the same effect on performance for all the interfaces, this would suggest that it was the task causing the effect, whereas if the effect on performance was different for the different interface styles, this would suggest that it was indeed due to the interface style. Third, interfaces on which users with particular characteristics did well were compared with the interfaces on which they did not do quite so well allowed the interfaces to be analysed in terms of the aspects in which they were similar to and different from the others. Fourth, the aspects of the interfaces with which the users with particular characteristics had difficulties was compared with the other interfaces on which the users performed better. This immediately suggested an alternative way of presenting the aspect.

Discussion

This experiment found that, out of the user characteristics, users' spatial ability related most strongly to performance (measured as time taken to complete a set number of tasks) on the different dialogue styles. The difference was most apparent using the command interface. This is shown in Figure 1.

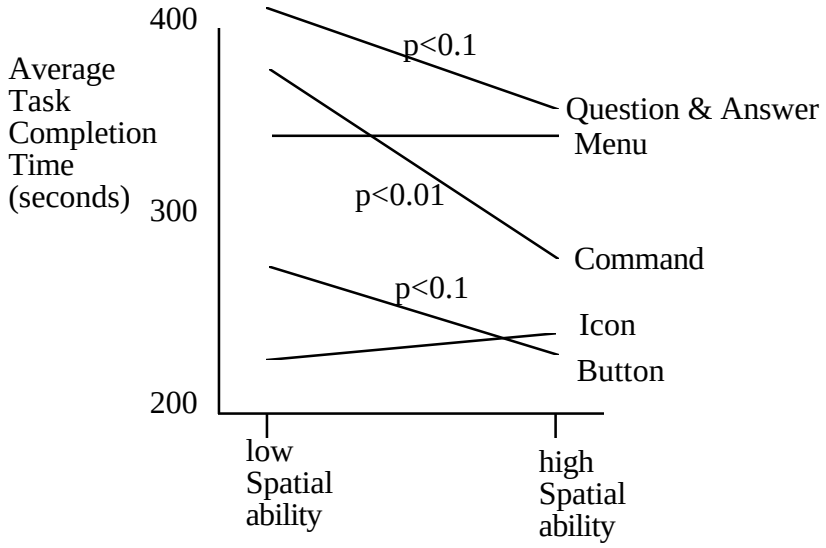


Figure 1 Correlations between spatial ability and task completion times for the five interfaces.

From Figure 1 it can be seen that people with high spatial ability do better on the command, question and button interfaces than people with low spatial ability, but do equally well on the iconic and menu interfaces. The command, question & answer and button interfaces all require significant *navigation* through the system to achieve the tasks, whereas the iconic and menu interfaces require this to a much lesser extent. The command language interface had three levels, or modes; a system level, the catalogue level and a help system. Although different system prompts indicated the different levels, the user had to keep in mind the level they were at, and how the levels linked together. The button and question & answer interfaces required the user to go through a series of hierarchical category choices in order to reach the item type they are interested in. The user had to understand this structure and be able to navigate around within it. The iconic interface however, after an initial choice of two categories, presented a

single visual scene from which the user could pick out the type of item they are interested in. The menu interface involved a walk-through menu in order to select the desired item type. The hierarchy of category choices is displayed as the user walks through the menu so that the structure does not have to be clearly remembered by the user.

These results suggest that spatial ability could relate to a user's ability to cope with an interface requiring navigation. Being able to cope with such navigation involves knowing where things are in the structure and how to move through the structure efficiently to reach them.

The difference in performance between the high and low spatial ability groups was much greater for the command interface than for the button and question & answer interfaces. This suggests that there is something additional about the command interface which is causing difficulty for users who have a low spatial ability. The command language interface involves a much less *constrained* dialogue than the other interfaces. In these, the interaction was quite structured and the user was presented with screens clearly indicating whether a category, item type or attribute choice should be made next, or an operation used to open, close or return to the start of the catalogue. However with the command interface a system prompt was displayed at all points, with little indication of what type of input is expected next from the user.

Spatial ability could therefore also relate to a user's ability to cope with interfaces allowing a very open and flexible dialogue. Being able to cope with a flexible dialogue involves being clear when and where particular input can be used to best advantage and what its outcome will be. However this latter result may be due to the fact that the users' spatial ability and field independence scores correlated significantly. 18 out of the 24 subjects were in the same group for spatial ability as they were for field independence i.e. in the high or low groups for both characteristics. It may in fact be field dependency which relates to the ability to cope with a flexible dialogue, as suggested by Fowler and Murray (1988).

The results of the preliminary study therefore suggested that at least two different interfaces are needed for an information retrieval system if it is to suit a range of users: one with a dialogue style which minimises navigation and constrains the dialogue for users with a low spatial ability, and one with a dialogue style which allows an open and flexible dialogue for users with a high spatial ability. These results would seem to confirm the results found by Vicente et al. (1987) and Vicente and Williges (1988) which seem to relate to a user's ability to navigate through a complex space.

Intuitively there appeared to be some conceptual spatial activities concerned with moving around open and flexible or hierarchical dialogues which was reliably measured by the spatial ability test we had used (Saville and Holdsworth) which involved the mental rotation of cubes. The notion of navigation in computer spaces has also been observed by Canter et al (1986) who argue that cognitive style is an aspect of human information processing which may explain differences in performance.

However, although users' spatial ability scores correlated with their performance on the interfaces, this does not necessarily show that users' spatial ability was causing the performance differences. Users' spatial ability scores may correlate with another variable which was actually causing the effects (Egan and Gomez, 1985). For example, there was a

significant correlation between subjects' field dependency and spatial ability scores suggesting that field dependency could have accounted for some of the performance differences (see Jennings, et al., 1991). It may be that the effect which we observed is actually something other than spatial ability or field dependence. Memory load may be influential or there may be a cognitive characteristic such as 'ability to move around information spaces'. Whatever the characteristic is called, providing it correlates consistently in this sort of task with the measure of spatial ability used, a problem does not arise. We are seeking a relatively stable and consistently measurable characteristic of humans which explains differences in performance on a well-defined type of task.

3. SECOND EXPERIMENT

The aim of this experiment was to test the hypothesis suggested by the preliminary experiment, namely that a constrained dialogue which minimised navigation would be most appropriate for users with low spatial ability and an open and flexible dialogue would suit users with high spatial ability. This was done by constructing two interfaces to an information retrieval system: a menu interface which minimised navigation and which constrained the dialogue - 'like a motorist in a one-way system' (Canter et al., 1986) - and a command style interface which allowed an open and flexible dialogue - 'like a ship's captain giving detailed directions to the helmsman' (Canter et al., 1986).

Users' previous experience with using interfaces akin to the two types of test system interface was considered in the experiment, even though no effects of previous experience were found in the preliminary study. The three point rating scale used in the preliminary experiment had proved too coarse-grained to ascertain any effects of experience.

Method

Subjects

Thirty subjects, eighteen male and twelve female, participated in this study. The subjects were graduates, aged between 25 and 40, who used computers as part of their everyday work for various tasks from word processing to programming. The subjects were paid volunteers.

Test system

An information retrieval system containing information about staff and students working at a university was constructed as the test system. The command interface was based on a restricted version of SQL; the *de facto* standard information retrieval query language. The interface supported queries of the form:
SELECT <attribute> FROM <relation> WHERE <condition1> AND <condition2>
SQL reserved words are shown in capitals, users supply the parameters (indicated by angle brackets), the WHERE clause being optional. For example,

SELECT name FROM staff
lists the names of all members of staff
SELECT name FROM staff WHERE course = 'English' AND position ='lecturer'

lists all members of staff who teach the English course and who have the position of lecturer

The interface allowed users to retrieve, edit and re-use previous command statements. A help system was provided giving the syntax for the SQL statements, and the users were provided with relation and attribute headings. A top level system command was required to move from the help system to the SQL interface and back.

The menu interface provided users with menus of options from which to select the relation and attribute they were interested in, and prompted the user to enter any conditions, clearly giving the user the form for entering these. The interface forced the user to go through a set sequence starting from the top level choice each time.

Both interfaces were designed to be as clear and as easy to use as possible. For example, for the menu interface, menu headings were designed to be as unambiguous as possible, crowded menu screens were avoided (Davis, 1989), and users were always provided with an escape to the top level (van Hoe et al., 1990). For the command interface, the line editing system used meaningful keys, for example control-F for moving the cursor forwards and control-B for moving it backwards. So that any differences in users' performances on the interfaces could be attributed to dialogue *style*, all other aspects of the interfaces were held constant. For example, both interfaces supported exactly the same range of queries and the same terms were used for database items and operations. Both interfaces operated using keyboard input only.

The information retrieval system was implemented in KEE on a SUN workstation. The information retrieval interfaces were displayed on the left hand side of the SUN workstation screen. On the right hand side of the screen the queries which the subject was required to answer using the information retrieval system were displayed.

Design and procedure

Each subject used both interfaces. The order of presentation of the interfaces was counterbalanced, half the subjects receiving the command interface first, and half the menu interface first. For each interface, subjects were given a practice session followed by a test session. For the practice session, subjects were given a series of queries to answer using the database, which were comparable to the queries which they would be asked to answer in the test session. The experimenter provided the subject with any necessary help, and the practice session was complete when the subject was confident that they had learned how to use the interface to answer the queries, and was happy to move on to the test session. No measurements were taken during the practice session and subjects could spend as long as they pleased practising. This was to ensure that all subjects had achieved a level of competence with the system equivalent to their completing a software training exercise. We were keen to exclude learning effects from this study.

In the test session the subject was required to answer the queries on their own without help from the experimenter. The complete session lasted approximately one hour, indicating that there were no excessively large differences between users during practice and test.

Subjects received different but equivalent queries to answer using the information retrieval system for the practice and test sessions for the two interfaces, to reduce practice effects while

maintaining comparability. The queries were balanced in terms of the amount and the complexity of the information which had to be extracted from the information retrieval system. A typical query was: 'list the names of all the members of staff who are lecturers on the maths course'.

To assess subjects' performance on the two interfaces, the times which subjects took to complete the test sessions with each of the two interfaces were recorded. Subjects were required to complete 12 queries. They were also given five point rating scales on which to rate how easy they found each of the interfaces to use, and were asked for any comments they had about what they liked or disliked about the interfaces. To measure the required user characteristics, subjects were given a spatial ability test to complete (Saville and Holdsworth), and were given five point rating scales on which to rate their levels of previous experience with using command and menu interfaces. The spatial ability test was a twenty minute written test, which required subjects to determine which of several drawings of cubes could be produced from given patterned cube nets.

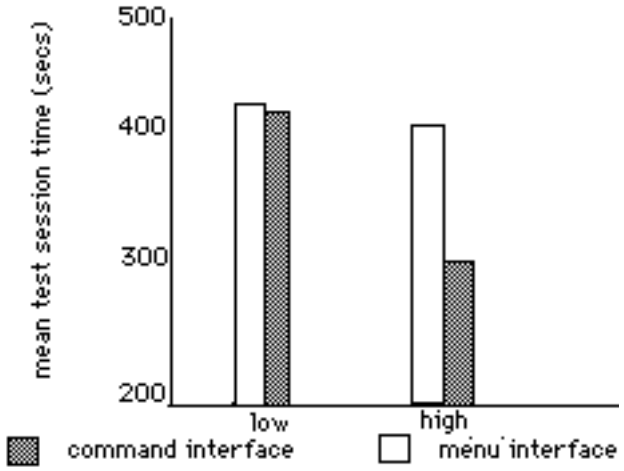
Results and discussion

The mean score on the spatial ability test for the thirty subjects was 57%, with a minimum score of 17.5% and a maximum score of 90%. Apart from two subjects who each made one error, all the subjects answered all the queries correctly using the two interfaces.

Test session times

The subject group was divided into two according to their spatial ability scores: a high spatial group for the subjects who scored above the mean score in the spatial ability test, and a low spatial ability group for the subjects who scored below the mean in the spatial ability test.
The low spatial group took a mean time of 401 seconds to complete the test session using the command interface, and 410 seconds using the menu interface. The high spatial ability group took a mean time of 303 seconds to complete the test session using the command interface, and 398 seconds using the menu interface. (See Figure 2).

A 2(spatial ability group) x 2(type of interface) analysis of variance showed that there was a significant interaction between spatial ability group and type of interface ($F(1,28)=8.00$, $p<0.01$). Simple effect tests for the low and high spatial ability groups showed that the low spatial ability subjects took a similar amount of time to complete the test session using the command interface and the menu interface ($F<1$), whereas the high spatial ability subjects completed the test session significantly faster with the command interface than with the menu interface ($F(1,28)=21.2$, $p<0.001$).



(Figure 2) Mean test session times with the command and menu interfaces for subjects in the low and high spatial ability groups.

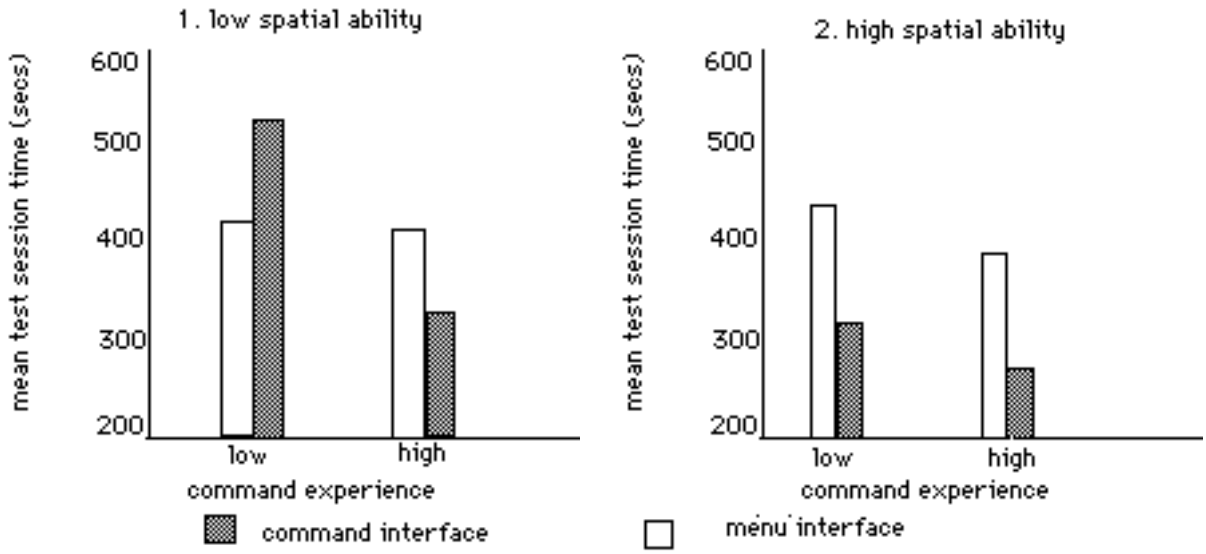
The above results did support the hypothesis that the command interface would be better than the menu interface for the high spatial ability subjects, as they did answer the queries quicker with the command interface. But the results did not support the hypothesis that the menu interface would be better than the command interface for the low spatial ability subjects, the interfaces proved equally good. In fact the results suggested that only the command interface would be necessary to suit all the users better or as well as the menu interface.

However, examination of the raw data showed that not all subjects had similar test session times for the command and menu interfaces, or always faster test session times using the command interface than using the menu interface. Six subjects in fact took longer to complete the test session using the command interface than the menu interface, so the menu interface did appear to be more suitable than the command interface for these subjects. All these subjects belonged to the low spatial ability group, and had rated their previous experience with using command style interfaces as low (i.e. four or five on the five point rating scale). Experience with command style interfaces therefore seemed important as well as spatial ability in deciding the more appropriate of the two interfaces for the users.

Six subjects in the high spatial group rated their previous experience with using command style interfaces as high (i.e. one or two on the five point scale), and six low (i.e. four or five). Similarly six of the subjects in the low spatial group rated their previous experience with command style interfaces as high, and six as low. The remaining six subjects rated their previous experience as intermediate (i.e. three). Mean test session times were calculated for each interface for the six high spatial ability and high experience subjects, for the six high spatial and low experience subjects, for the six low spatial and high experience subjects and for the six low spatial and low experience subjects. (See Figure 3).

Separate 2(command experience) x 2(type of interface) analyses of variance were carried out for the low spatial ability subjects and the high spatial ability subjects. The low spatial ability subjects' analysis showed that there was a significant interaction between previous experience and interface type ($F(1,10) = 46$, $p<0.0001$). Simple effect tests for the low and high experience groups showed that the low experience subjects performed significantly faster on

the menu interface than the command interface ($F(1,10) = 22.1$, $p<0.001$), while the high experience subjects performed significantly faster on the command interface than on the menu interface ($F(1,10) = 23.9$, $p<0.001$). The analysis of variance for the high spatial ability subjects showed that there was no significant interaction between previous experience and interface type ($F<1$), but that there was a main effect of interface type ($F(1,10) = 87$, $p<0.001$), and the main effect of previous experience approached significance ($F(1,10) = 2.72$, $p = 0.13$). All the high spatial ability subjects performed faster on the command interface than the menu interface, and the subjects with a high previous experience of command style interfaces performed slightly faster on both interfaces than those with a low previous experience.



(Figure 3) Mean test session times with the command and menu interfaces for low and high spatial ability subjects with low and high command experience.

These results suggested that the command interface was more suitable than the menu interface for all subjects with high spatial ability, whatever their previous experience, and for subjects with low spatial ability but high experience of command style interfaces. Whereas the menu interface was more suitable than the command interface for subjects with both low spatial ability and low command experience.

The results showed that many limitations on subjects' performance on the command interface, which related to their spatial ability, could be overcome with experience. However, a scatter plot of subjects' spatial ability scores against their test session times for the command interface which gives their command experience, shows clearly that not all the limitations of low spatial ability are overcome by high experience. (Figure 4). For just the high experience subjects, there is a significant Pearson product moment correlation coefficient between subjects' spatial ability scores and their test session times ($r = -0.69$, $df = 10$, $p<0.02$), showing that even for subjects with a high level of experience their performance is worse the lower their spatial ability.

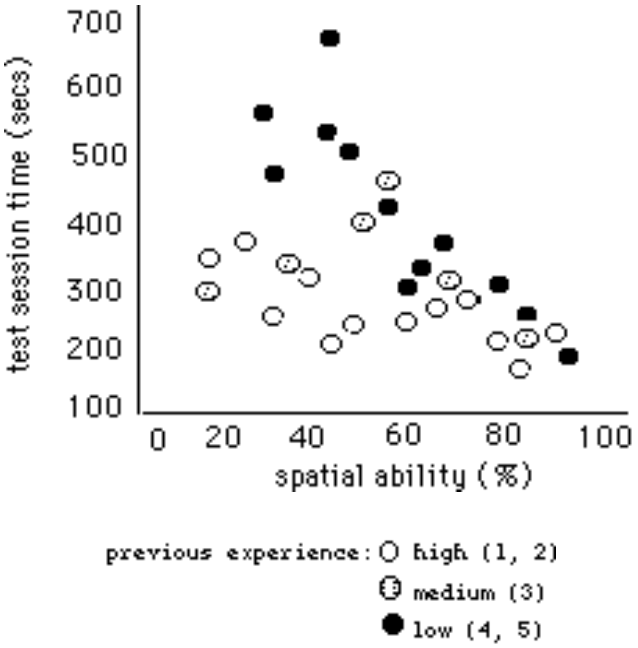


Figure 4 Subjects' test session times for the command interface against their spatial ability scores, giving their command experience

Ease ratings

Mean ease ratings were calculated for each interface for the six high spatial ability and high command experience subjects, for the six high spatial and low experience subjects, for the six low spatial and high experience subjects and for the six low spatial and low command experience subjects. (See Figure 5).

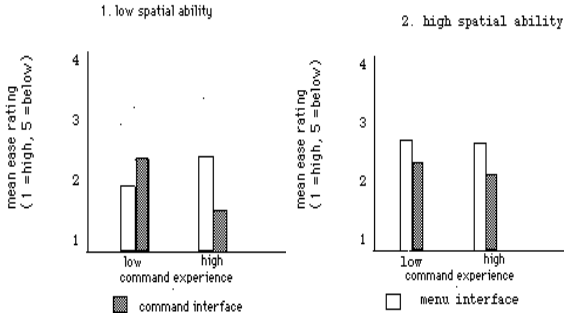


Figure 5 Mean ease ratings for the command menu interfaces for low and high spatial ability subjects with low and high command experience.

To examine the ease ratings, separate 2(command experience) x 2(type of interface) analyses of variance were carried out for the low spatial ability subjects and the high spatial ability subjects. The low spatial subjects' analysis showed that there was a significant interaction between previous experience and interface style ($F(1,10) = 5.87$, $p<0.05$). Simple effect tests for the low and high experience groups showed that the ease ratings for the two interfaces did not differ significantly for the low experience subjects ($F(1,10) = 1.29$, $p>0.1$); but that they did differ significantly for the high experience subjects ($F(1,10) = 5.17$, $p<0.05$). The analysis of variance for the high spatial ability subjects, showed that there was no significant

interaction between previous experience and interface type, and no significant main effects of previous experience or interface type (all Fs<1).

The directions of the means of the ease ratings (Figure 5) followed the same pattern as the means for the test session times (Figure 3) for each interface, in terms of the within-subjects results. Although only one of the differences actually reached significance in this case, the fact that the directions were the same suggested that this qualitative data lent some support to the conclusions drawn from the quantitative test session times data. The between-subjects comparison of ease ratings for the interfaces was unreliable for this qualitative data, as different subjects interpreted the points on the rating scales differently.

Comments

Subjects who liked the menu interface more than the command interface, made comments such as the following about the menu interface:

- 'needs very little thought'
- 'no need to remember syntax'
- 'didn't let you make mistakes as much'
- 'prompted at each stage'

and comments such as the following about the command interface:

- 'instructions have to be committed to memory'
- 'involved translating from natural language into programming language'
- 'had to learn the structure of the query'

Subjects who liked the command interface more than the menu interface, made comments such as the following about the command interface:

- 'compact ... short cuts available ...'
- 'able to request information in a single step'
- 'could recall and edit commands'

and comments such as the following about the menu interface:

- 'slow and repetitive, frustrating'
- 'laborious'
- 'tedious, starting from beginning each time'

These comments suggested that it was the degree of navigation and the openness and flexibility of the dialogue allowed with the two interfaces which was determining whether subjects liked one interface more than the other. References to having to remember syntax and being able to recall and edit commands for the command interface, and to the menu interface prompting at each stage and not allowing mistakes as much, all relate to the constraints of the dialogue. Comments about having to start from the beginning each time to access a new piece of information with the menu interface relate to the degree of navigation.

Discussion

The results of this experiment suggest that an interface with a dialogue style which minimises navigation and constrains the dialogue, such as the menu interface in this experiment, is suitable for users with both a low spatial ability and low experience of using command style interfaces. Whereas an interface with a dialogue style which allows an open and flexible dialogue, such as the command interface in this study, is suitable for all users with a high spatial ability, whatever their previous experience, and for users with a low spatial ability but high experience of using command style interfaces. According to these results, a command style interface only would suit all users, if all users with a low spatial ability could gain experience of using command style interfaces. However, although frequent users of a computer system may be able to do this, it is unlikely that occasional users would be able to gain enough experience, and the menu style interface would be necessary for this user group.

It is not clear whether the results of this study are generalizable to other subject groups. It may be that a non-graduate subject group could contain some subjects with lower spatial abilities than the subjects in this graduate group. Subjects with a very low spatial ability may not be able to overcome their performance difficulties on the command interface by increasing their experience, in which case all very low spatial ability users may be better off with the menu interface than the command interface whatever their experience. In fact, the positive correlation which was found between performance on the command interface and spatial ability score for the high experience subjects, supports the idea that very low spatial ability subjects would have performance difficulties on the command interface even when their experience is high. This may result in their performance on the command interface actually being worse than that on the menu interface, performance on the menu interface appearing relatively free from effects of spatial ability.

It is also not clear whether the results are generalizable to more complex uses of SQL for the command interface. The SQL statements which users were required to formulate for the command interface were relatively simple. None of the statements involved the subjects having to link two relations. If the use of SQL had been more complex for the command interface, it may be the case again that the low spatial ability subjects could not produce a good performance on this interface whatever their previous command experience. One subject with a very low spatial ability but high previous experience, who produced a faster time for the command interface than for the menu interface, commented that if the use of SQL had been more complicated he probably would have preferred the menu interface to the command interface.

4. CONCLUSIONS

This study has suggested that different users of information retrieval systems are suited to interfaces with different dialogue styles. There appears to be an interesting interplay between cognitive characteristics and personal profile data. In this experiment command language experience appeared to have an effect, but experience is dependent on other factors such as frequency of use. Information retrieval access is one application of computer technology which must be available to discretionary and intermittent computer users.

This study has spoken of the dialogue style for an information retrieval system interface as if it can be considered in isolation from the database which the interface forms part of. Others (e.g. Reisner, 1980) have suggested that the users conceptual model of the data may have an influence (e.g. if they conceptualise the data as a hierarchy or as a 'flat file' database). Data

entry is also an important issue. The type of data entry which an information retrieval system needs to support may in fact limit the interface dialogue styles which are possible for the system. Similarly, the size and complexity of the information space is important. Information retrieval (bibliographic) databases, for example, typically do not have many interlinked files, allowing a more prescribed interaction than information retrieval systems which do have interlinked files.

The influence of cognitive style is important. Although other researchers have argued that cognitive style is most influential during the learning phase (Ulrich, 1987; Kottemann and Remus, 1988), it appears from our own work and that of (Egan, 1988; Vicente and Williges, 1987) that certain characteristics are important after the learning stage. This experiment confirmed the findings of Vicente and Williges (1987) concerning spatial ability; a characteristic also singled out by Egan (1988) and van der Veer (1990).

This experiment demonstrates not just the feasibility of the adaptive mechanisms, but the feasibility of finding and recording cognitive characteristics which effect the interaction. The contention is that the user makes mistakes *because* they have a poor spatial ability and the command interface requires them to have a good one. We are able to infer the domain **in**dependent characteristic of spatial ability because of the characteristics of the command interface. Since spatial ability is domain independent we can then use this knowledge when the user interacts with other systems.

There are many different types and measures of spatial ability (Dillon, 1985; Dillon and Schmek, 1983) and it is unclear at present which are most relevant to using computer systems. Clearly further work does need to be done to establish more precisely the relationship between dialogue styles and cognitive characteristics,. However the amount of navigation demanded by an interface does appear significant. Navigation is of central concern to designers and users of hypermedia systems (e.g. Sellen and Nicol, 1990) and has been commented upon in other systems (Canter, et al., 1986). The navigation metaphor is also relevant to the notion of cognitive maps (Neisser, 1987) where the importance of landmarks has been stressed. Although the results presented here have been expressed in terms of the cognitive characteristic of spatial ability and in terms of the interface characteristics of openness and flexibility (since they are the measures which we used), there may be further insights to be gained by considering a cognitive characteristic of 'navigational ability' and interface 'landmarks' which clearly identify what is achievable at various points in the dialogue and 'signposts' which indicate appropriate directions. Whatever the metaphor, the problem of different users have different abilities which are difficult for the users to change should be considered by interface designers.

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