THE ROLE OF HUMAN MEMORY IN THE EXTERNAL STORAGE AND RETRIEVAL OF INFORMATION: VOL 2.

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6. EXPERIMENT TO INVESTIGATE THE FACTOR(S) CONTRIBUTING TO A STRONG SPATIAL 'IMAGE'

6.1 Introduction

It is evident from the comparison of results from experiment 1 and experiment 2 (section 5.7) that the spatial 'image' formed of the pigeon hole array job categories was superior to that of random lists of the same categories. It was necessary to discover which aspect(s) of the pigeon hole array contributed to this superiority; thus enabling us possibly to compensate for the poor quality of the spatial 'image' of computer displays by including analogues of the feature(s) found to be important.

6.2 Basic considerations

There are three major sources of cues which could be responsible for the superiority of pigeon hole arrays, compared to random lists, in terms of spatial memory. The first is the larger size of the pigeon holes in comparison to the list of categories. The second is due to the extensive motor component involved in putting information into pigeon holes as opposed to ticking a category in a list and then putting the information item into a pile. The third concerns the fact that the pigeon holes and their corresponding job categories were arranged in two dimensions as opposed to the uni-dimensionality of the list. Therefore, three corresponding experiments are necessary to determine which of these factors are important.

6.3 Experimental rationale

The rationale for each of the three experiments will be discussed in turn:

i) Two dimensionality:

To ascertain the contribution of two-dimensionality to the spatial 'image' it was impractical to re-arrange the pigeon hole array into one dimension. However, it was practical to re-arrange the uni-dimensional random lists of job categories into two dimensions and then compare the results with those of spatial recall in experiment 2.

ii) Size:

In order to determine whether the size of the pigeon holes was an important factor contributing to the spatial 'image' it was necessary to repeat experiment 1 condition 3 with a smaller version of the pigeon hole array. This particular condition was chosen because it involved only spatial recall, which was all that was of interest. The task to be repeated was basically a motor action associationed with locations in a two-dimensional array, but on a smaller scale. It was not possible to use a miniature version of the pigeon holes <u>per se</u>, so a diagrammatic scaled-down version of the pigeon holes was drawn. The motor action to each location would still be preserved (subjects would enter a tick), but scaled down somewhat, whilst fulfilling the experimental requirements.

iii) Motor component:

Investigation of this aspect necessitated the repetition of experiment 1 condition 3, using the pigeon holes, but without actually placing the items of information into the various locations. Instead the subjects would be required to report the appropriate locations, via its row and column number, and then to place all the information items on one pile. This would still require eye movements, but not the gross movements of the upper limbs.

If filing without motor movements and with a smaller pigeon hole array both caused a detriment in the previously obtained spatial recall measure, we could conclude that motor movements and stimulus display size were important contributors to an effective spatial 'image' in memory. If the introduction of two dimensionality to random lists caused an increase in spatial recall measures, we could conclude that the two dimensional organisation of information items enhances the spatial 'image' of them in memory.

6.4 Method

The methods for all three experiments were exactly the same as those previously used in the three experiments with which we are to compare results except for the actual filing task. These were as follows:

i) Two-dimensions:

Figure 6.1 shows an example of the two-dimensional random arrays of job categories used in the experiment. The method was precisely the same as that used in experiments 2-5, each item being classified by ticking the appropriate job category.

ii) Size:

Figure 6.2 shows the smaller, diagrammatic version of the pigeon holes used in the experiment. To file items the procedure was the same as in experiment 1 condition 3, except that instead of placing information sheets into pigeon holes the appropriate location was ticked, thus preserving, in scaled-down form, the motor and two-dimensional components. The diagram of the pigeon holes was placed in front of subjects; as was the pigeon hole array originally used.

iii) Motor:

For this experiment, the pigeon hole array of experiment 1 was used. The task was to read an item of information, decide upon the appropriate job category and give the co-ordinates of its location; for example, C1R2 (column 1, row 2). Each item of information was then placed in a pile in front of the subject; thus the original gross motor component was removed. The rest of the procedure was the same as that used for experiment 1 condition 3.

Nine subjects were used in each experiment and were selected from three groups; these were computer professionals, non-computer professionals, and secretaries. The subject groups were balanced across the three experiments, three from each subject group in each experiment.

Figure 6.1. The random two-dimensional array of job categories used to investigate the two-dimensional component of the spatial 'image'.

Tourism	Civil service	Retailing
Entertainment	Engineering	Industrial administration
Medical	Insurance	Advertising
Legal work	MSc courses - Social sciences	Social work
Quality control	Local authority	Public transport
PhD research	MA courses - Arts	Management services
Journalism	Banking	Management training
Armed forces	Buying	Stockbroking and investment analysis
Hotel management and catering	Part-time education	MSc courses - Physical sciences
Teacher training	Accountancy	Environmental control and design

Figure 6.2. The small 'pigeon hole' array used to investigate the size component of the spatial 'image'.

BUYING	TOURISM	STOCKBROKING AND INVESTMENT ANALYSIS	PUBLIC TRANSPORT	JOURNALISM	
MSC COURSES - PHYSICAL SCIENCES	INSURANCE	BANKING	ENGINEERING	LEGAL WORK	
MEDICAL	PART-TIME EDUCATION	LOCAL AUTHORITY	ENTERTAINMENT	MANAGEMENT TRAINING	
INDUSTRIAL ADMINISTRATION	QUALITY CONTROL	MANAGEMENT SERVICES	HOTEL MANAGEMENT AND CATERING	ACCOUNTANCY	
MSC COURSES - SOCIAL SCIENCES	TEACHER TRAINING	MA COURSES - ARTS	SOCIAL WORK	PHD RESEARCH	
ADVERTISING	ENVIRONMENTAL CONTROL AND DESIGN	ARMED FORCES	CIVIL SERVICE	RETAILING	

6.5 Results and analysis

The results obtained are listed in tables 6.1 to 6.4. Tests for homogeneity of variance found that variance ratios were not consistently within an acceptable range to allow the parametric t-test to be validly used. Therefore, analysis was undertaken with the 'Omnibus' program used in preceding experiments.

The results of the numbers of job categories recalled for the various experimental comparisons can be seen in tables 6.1 and 6.2; the former shows results from the experiments previously described and the latter the results from the relevant earlier experiments. The statistical comparisons were as follows (using 'Omnibus'):

2D vs. Size: NS ($p > 0.05$)
Size vs. Motor: NS ($p > 0.05$)
2D vs. Motor: 2D > Motor ($p < 0.05$)
2D vs. Exp 2, CSR: NS ($p > 0.05$)
Size vs. Exp 1, Cond. 3: NS ($p > 0.05$)
Motor vs. Exp 1, Cond. 3: NS ($p > 0.05$)

There was no significant difference in the number of job categories recalled between the 2D random and size arrangements, and the size and motor arrangements. However, significantly more job categories were recalled using the 2D random arrangement compared to the motor experimental arrangement. Furthermore, there was no significant differences between these respective experiments and their earlier counterparts.

Table 6.3 lists the spatial recall results, ATE, %SS and %O, for the investigation of two dimensionality and the comparable results from experiment 2, CSR. Table 6.4 lists similar results for the determination of the contribution of the motor and size components to the spatial 'image'.

	2D	Size	Motor
S1	28	26	24
S2	28	27	24
S3	28	25	21
S4	28	24	29
S5	26	22	25
S6	27	29	23
S7	23	27	24
S8	29	24	19
S9	28	23	27
$\bar{x}$	27.2	25.2	24.0

Table 6.1. <u>The number of job categories recalled in each of the experiments concerning 2D, size, and motor aspects of the spatial 'image'.</u>

	Experiment 2 CSR	Experiment 1 Condition 3
S1	23	21
S2	29	28
S3	29	27
S4	26	29
S5	26	27
S6	28	25
S7	29	29
S8	29	28
S9	25	24
$\bar{x}$	27.1	26.4

Table 6.2. <u>The number of job categories recalled in experiment 2, CSR, and experiment 1 condition 3.</u>

	2D			Experiment 2 - CSR		
	ATE	%SS	%O	ATE	%SS	%O
S1	0.18	100.0	82.14	2.52	80.95	30.43
S2	0.75	100.0	53.57	3.21	62.07	17.24
S3	1.32	92.86	57.14	1.34	79.31	27.59
S4	1.10	96.43	53.57	1.42	88.46	42.31
S5	0.38	100.0	69.23	2.31	73.08	30.77
S6	1.59	92.59	51.86	1.71	85.71	21.43
S7	1.83	91.30	47.83	2.28	82.76	24.14
S8	1.03	96.55	51.72	3.97	68.97	20.69
S9	0.43	100.0	71.43	3.72	84.00	28.00
$\bar{x}$	0.96	96.64	59.83	2.50	78.37	26.96

Table 6.3. Spatial recall parameters and related results for comparison of the effect of 2-dimensionality.

	Motor		Size		Experiment 1 Condition 3	
	ATE	%O	ATE	%O	ATE	%O
S1	0.42	66.67	0.27	76.92	0.24	76.2
S2	0.67	58.33	0.59	74.07	0.61	78.6
S3	0.62	52.38	0.32	80.00	0.37	44.1
S4	1.13	45.40	0.33	83.33	0.00	100.0
S5	0.23	76.73	1.14	31.82	0.33	70.4
S6	1.10	51.23	0.45	62.07	0.44	72.0
S7	0.33	79.17	1.04	48.15	1.17	51.7
S8	0.47	57.89	0.67	58.33	0.71	57.1
S9	0.19	81.48	0.13	86.96	0.96	41.7
$\bar{x}$	0.56	63.25	0.58	57.19	0.54	65.76

Table 6.4. Spatial recall parameters and related results for comparison of the effect of the motor and size components.

i) ATE:

2D vs. Exp 2, CSR: 2D $<$ Exp 2 ($p < 0.001$)

Motor vs. Exp 1, Cond. 3 : NS ($p > 0.05$)

Size vs. Exp 1, Cond. 3 : NS ($p > 0.05$)

ii) %SS:

2D vs. Exp 2, CSR : 2D $>$ Exp 2 ($p < 0.001$)

iii) %O:

2D vs. Exp 2, CSR : 2D $>$ Exp 2 ($p < 0.001$)

Size vs. Exp 1, Cond. 3 : NS ($p > 0.05$)

Motor vs. Exp 1, Cond. 3 : NS ($p > 0.05$)

The only factor which exhibits any significant difference in comparison with corresponding earlier experiments is two-dimensionality: for ATE, 2D is significantly less than experiment 2, CSR; for %SS and %O, 2D is significantly greater than experiment 2, CSR.

6.5.1 The nature of the specific spatial model of the two-dimensional array of job categories

The spatial profile representing the nine subjects of the 2D experiment can be seen in table 6.5. As with the pigeon holes, there was no apparent pattern in terms of the number of job categories recalled per position. However there was a distinctive pattern in the distribution of the %O scores.

Rows 1,2,9, and 10 $>$ rows 3,4,5,6,7, and 8 ($p < 0.001$)

Column 1 vs. column 2 vs. column 3 NS. ($p > 0.05$)

Therefore, location accuracy is greater at the top and bottom of each group of job categories, but not greater in the outer groups compared with the middle one.

	NO. REC.	%O		NO. REC.	%O		NO. REC.	%O
1	8	87.5	11	7	85.7	21	8	87.5
2	8	87.5	12	7	57.1	22	6	50.0
3	7	71.4	13	8	37.5	23	7	42.9
4	8	37.5	14	8	50.0	24	6	33.3
5	9	44.4	15	8	50.0	25	8	37.5
6	8	50.0	16	6	33.3	26	8	12.5
7	9	44.4	17	6	33.3	27	8	50.0
8	9	44.4	18	8	75.0	28	8	62.5
9	7	100.0	19	8	75.0	29	6	83.3
10	9	88.9	20	6	100.0	30	8	100.0

Table 6.5. The specific nature of the subjects' spatial model - profile of number of categories recalled and %O, averaged across the 9 subjects for each position of the 2D stimulus array.

6.6 Discussion

There was no significant difference, in terms of the number of categories recalled, between each of the three experiments and their respective comparison experiments (experiment 2, CSR, or experiment 1, condition 3). Similarly, there was no significant difference between the numbers recalled in the 2D experiment and the size experiment, and the size and motor experiments. This suggests that an effective categorical memory model is developed irrespective of the spatial characteristics of the filing task. However, there was a clearly significant difference between the 2D and motor experiments; it is possible that having to specify pigeon holes using row and column codes could interfere with subsequent category identity recall, but the lack of significant difference between the size and motor experiments renders the whole argument somewhat shaky.

Results were clearer regarding the relative effects of the three experiments on subjects' spatial location models.

The use of two-dimensionality in the grouping of job categories improved spatial location ability, as reflected by ATE, %SS, and %O, and there was also evidence of a specific pattern of of location accuracy. However, the increase in location accuracy and the corresponding pattern were not reflected in the numbers of job categories recalled. This adds further support to our theory of an independent categorical and spatial memory.

For the specific pattern of location accuracy, as reflected by %O, to follow that of the pigeon holes, we would expect not only the top and bottom of each section but also the outer sections to show higher values. However, this was not the case. There was a significant difference in %O ($p < 0.001$, Omnibus) between rows 1, 2, 9 and 10, and the other rows (see table 6.5), but none between the sections ($p > 0.05$, Omnibus). This would suggest that two-dimensionality was not involved and that the stimulus array was being regarded as three separate lists;

each list exhibiting a typical 'list' profile. If we compare this two dimensional spatial grouping into three lists with the division of one dimensional lists into five sections (experiment 3), we find that the former shows a significantly greater degree of spatial location accuracy ($p < 0.05$, Omnibus). Furthermore, in the absence of any influence of two-dimensionality upon the internal spatial model, we would expect five groups of six to be more perceptually efficient than three groups of ten. Therefore, we must conclude that the introduction of two-dimensionality contributes significantly to a stronger spatial memory model. In fact, a comparison of the results of the 2D lists with those of the pigeon holes (experiment 1, condition 3) shows no significant difference between them ($p > 0.05$, Omnibus), indicating spatial models of approximately equal strength.

The slight difference in profiles, between pigeon holes and the two-dimensional lists, can be accounted for in terms of the distribution of the job categories. Pigeon-hole job categories were evenly distributed in a two-dimensional array, each being allotted a uniformly sized area; perceptually rows and columns were equally dominant. Alternatively, the two-dimensional lists did not exhibit the same degree of uniformity, the job categories being distinctly grouped across the page. In this case, columns were perceptually more dominant than rows. Therefore, the pigeon hole array was perceived in total, the main points of reference being the perimeter locations, whereas the two-dimensional lists were perceived as three separate groups of job categories arranged across the page. In the latter case, the points of reference would be the top and bottom of each separate group.

The reduction in size, or the lack of motor cues, did not produce any significant change in the subjects' ability to locate items. There is one important implication that we can draw from these results in terms of screen formatting. A scaled-down graphic analogue of a pigeon hole array confers a spatial model equal in strength to that of a full size array.

However, we must bear in mind that the sensitivity of the experiments might not have been sufficient to reflect the contribution of these subtle cues.

6.7 Conclusion

The major contributory factor to the efficacy of the spatial model of the randomised pigeon holes, in comparison to the randomised list, was the inherent two-dimensional organisation of descriptor locations.

7. COMPARISON OF MEMORY MODELS ARISING FROM THE USE OF 2- AND 4- LEVEL INDEXES

7.1 Introduction

The initial survey of personal office filing systems (see chapter 3) demonstrated that generally they were only organised to two levels of categorisation, functionally within the context of a person's job. It was also noticeable that, unless the filing system was large and complex, an index was rarely referred to in order to locate an information item, although users often took the trouble to construct one.

In chapters 4 to 6 the nature of the categorical and spatial memory models, arising from simulated conventional filing (labelled pigeon holes) and computer filing (lists of information category labels), were investigated; this was in order to ascertain the form of external information organisation which could be most effectively represented in human memory.

To use a filing system successfully a person must have an internally stored model concerning the externally stored information. This enables the identification of the relevant information items and also the initiation of an appropriate retrieval strategy based upon the strategy used in storage. Information is stored internally according to some form of organisation in order to provide meaningful interpretation of incoming material, and to facilitate the retrieval of information at some later time. It follows that any external store of information should be similarly organised for the same reasons. Within the context of the present research it is of interest to discover the type of organisation which is optimally suited to the use of computer filing systems. Are two levels adequate, as in non-computer office filing systems, or is a more elaborate organisation necessary for efficient interaction, considering the lack of spatial cues in computer displays? The organisation of information according to an efficient categorical retrieval plan would seem the most productive approach. An efficient index would serve as both a storage and retrieval aid and to mediate the development of an efficient internal categorical model appropriate to the use of computerised information.

With the future likelihood of increased use of computers for information storage and retrieval by non-computer professionals, the type and complexity of indexing will become an important issue. It could be useful, therefore, to ascertain the type of index which offers users the conceptual model most compatible with their needs. The following experiment although it only scratches the surface, may give some indication of this. First, however, it is pertinent to look at some relevant literature concerned with information organisation in memory.

7.2 Literature survey

Shannon (1949) defines information as essentially a selection amongst alternatives. In other words information serves to, in information theory terms, to reduce uncertainty. In the normal environment most perceptible objects and events are meaningful; they afford various possibilities for action, carry implications about what has happened and what will happen, belong coherently to a larger context, and possess an identity which transcends their simple physical properties. Meaning can be and is perceived. However, this perception depends upon the person who is perceiving, in terms of information already stored in his memory, and the context within which it takes place. Every persons' possibilities for perceiving and acting are entirely unique, because no one else occupies exactly his position in the world or has exactly his history. Therefore, the provision of higher levels of definition, and the concomitant increase in definition amongst alternatives, will increase the meaningfulness of information and serve to decrease uncertainty.

Meaning can only exist for an information item in relation to other information items (Anderson and Bower, 1973). To understand a concept it must be defined in terms of other concepts, which in turn are defined in terms of other concepts, an essentially hierarchical structure. The interpretation of information items can therefore be considered to be the relating of them to a vast organised store of related concepts, and that no meaning can be independent of that organisation (Bousfield, 1953; Bower et al., 1969; Tulving and Pearlstone, 1966). However, in providing the basis for the interpretation of an information item the internal store of knowledge itself becomes modified.

Miller, Gallanter and Pribram (1960) postulate that information is organised in memory according to some 'plan'. However, the plan analogy suggests a rather static organisation of information. 'Schema' is a better word for the central cognitive structure involved in perceiving and storing information (Bartlett, 1932). The schema is not only the plan but the executor of the plan; a pattern 'of' action as well as a pattern 'for' action. Perception of meaning, like the perception of any of the other aspects of the environment, depends on the schematic control of information pick up according to a strategy. In a similar way an index used in conjunction with a filing system can serve to act as a basis for a strategy of information storage and retrieval in the 'schema' of interaction with an external filing system. The preceding discussion suggests that greater strategic organisation of information provides a stronger cognitive model of that information and consequently a more successful storage and retrieval strategy.

The purpose of a storage and retrieval strategy is to provide the subject with a set of retrieval cues for the to-be-recalled material. Retrieval schemes such as mnemonic systems involving the use of a well-memorised list of cues are very efficient high-level retrieval plans. Although there is ample evidence that the use of mnemonic systems can markedly facilitate recall (Wood, 1967a), they are not effective for all kinds of material. Bower (1970a) indicates that forming higher order memory units is a low-level retrieval plan; associating two higher order units is a slightly higher-level retrieval plan. Although these retrieval plans are considered to be low level, they are more general than the mnemonic system type in that they can be used to recall many kinds of verbal material. Moreover, in some cases at least, the memory units may be organised in such a way that the subject has an excellent retrieval plan. If the to-be-remembered material is organised in a hierarchical fashion, then the hierarchical order provides the means for subjects to move from one memory unit to the next, or a way to form one large memory unit. When we externally organise information we may define 'low-order' units (e.g. files) in terms of 'higher order' units (e.g. administration section). The nature of encoding, with respect to level of processing, appears to be one of the most important factors affecting learning; and hence the integrity of the cognitive model of the information.

Tresselt and Mayzner (1960) studied free recall of a list of words in an incidental learning paradigm as a function of three different levels of orientation. They found that the higher the level of processing of the material, the greater the degree of learning, or the slower the rate of forgetting, or both. This would suggest that extensive organisation of information into higher semantic levels would result in a better cognitive model of the information. This would be especially true in situations where categorical cues were prevalent (as is the case with much storage and retrieval of information in computers). Bower et al. (1969) and Cohen and Bousfield (1956) found that recall was indeed better for hierarchically organised material. In the Bower et al. study, recall was 2-3 times better for hierarchical organisation than for random presentation. Durding (1977) noted that people were capable of classifying information to 4 or 5 hierarchical levels, especially when some form of prompt template was provided.

Work described earlier (chapters 4 and 5) suggests that the explicit display of information organisation serves to establish a cognitive model exhibiting a similar organisation. It would seem logical, therefore, that the encouragement of the formation of an hierarchical memory model, via a multi-level index, would enhance the subsequent accessibility of information; this would be due to a stronger, more definite, and more efficient plan being available for the purpose of information storage and retrieval. However, how extensive should this organisation be?

7.3 Experimental aims

The basic aims of the experiment were to discover:

a) which was easier to use, a two- or four-level categorical index,

b) which index produced the stronger cognitive model in terms of speed and accuracy of decision.

The intention was not only to test the index for speed and accuracy for use, reflecting the general efficiency of the cognitive model, but also to reflect the strength of the model in terms of specific storage characteristics of the information.

7.4 Basic considerations

The initial survey of office personal filing systems (chapter 3) revealed that people were usually content to organise their information functionally to two levels. There are two possible reasons for this; either two levels are conceptually most suitable, or personal motivations and external constraints restrict further organisation.

Experiment 1 (chapter 4) indicated that meaningful categorical organisation did not seem to be of paramount importance when developing an efficient cognitive model of a simulated 'real world' filing system. This was, perhaps, due to the availability of strong spatial cues. However, filing via a simulated computer file list, as in experiments 2-5 (chapter 5), demonstrated that explicit categorical organisation was important when locating a file descriptor in each list.

The job category lists used in experiments 2 to 5 were progressively categorically organised to two levels, and although this improved 'location memory', compared to random arrangement, it does not mean that this was the optimum number of levels for the strongest possible memory model. The present experiment sets out to discover whether a two level or four-level system fulfils this. There are four possible reasons for the lack of organisation in most 'real world' personal filing systems. Firstly, two levels of categorisation may facilitate the best cognitive model in relation to the filing context. Secondly, lack of motivation and occupational time constraints may be responsible. Thirdly, a broad functional classification scheme generally only lends itself to two levels of organisation and prevents fragmentation of information. Lastly, it is possible that most of the filing systems surveyed were within the bounds of spatial memory; indexes would have to be used with large and complex systems because they would be outside the bounds of spatial memory.

Successful examination of the previous issues necessitates the removal of the spatial information environment in keeping with a computer system, the elimination of motivational and occupational time constraints, and the use of information equally meaningful to many people rather than biassed towards certain individuals (as it would be in a personal filing system). Although people usually only go to two levels of organisation, if a multi-level system initiates a better cognitive model, people could be encouraged to use this type of classification in systems. Yikes! ESH etc completely ignored!

If a multi-level system was found to provide the best cognitive model, rather than a two level system, it is likely that motivation and time available, functional classification, and an efficient spatial memory are responsible for lack of organisation in the 'real world' situation.

A major problem, however, was to employ measures which would reflect the efficiency of use of the cognitive model of the two kinds of indexes, and also reflect storage characteristics. Efficiency of use could be reflected by time and error scores in using the index. But to reflect storage characteristics some form of retrieval of information was needed. Free recall could be used if it were not for the fact that the indexes necessitate a large number of descriptors, compounding the weaknesses in this technique previously described in experiment 1. Another alternative would be to require subjects to make a decision based on information from the stored cognitive model; for instance, some form of recognition task. A recognition task would be easier to use and allows easier quantification of results. However, there is some debate as to whether recognition and recall rely on the same memory processes.

7.5 Recognition or recall?

Any experiment formulated would involve the coding of a substantial number of descriptors using different indexes. The subsequent recall of these words, especially after a fairly long period to ensure the reflection of long term memory storage, would be somewhat impractical from the point of view of mental load on the subjects, the time period involved, and the control and standardisation of output. A more practical method for testing the cognitive model would be by a simple yes/no recognition task. However, for this to be valid it is important that the effect of the semantic organisation of stimulus material on the cognitive model is reflected in this method of testing. There are conflicting reports in the literature which contest this validity.

Both Bower (1968) and Kintsch (1968) showed that while experimenter organised lists produced the well known facilitating effect in recall, they did not show any differences in recognition. Kintsch summarised this point of view most emphatically by saying that organisation "can have no effect upon recognition, since organisation facilitates retrieval and only recall involves retrieval".

There were assumed to be two stages in output from memory. The first stage was the retrieval of relevant memory traces. The second stage was the decision as to what response to make based on the traces received. The retrieval process was assumed to operate on memory storage, using the retrieval cues (stimuli) as input to retrieve (access) the relevant memory traces.

It was considered reasonable to assume that the decision rule used by the recall decision process was to output the response which had the greatest retrieval strength of association with the stimulus (retrieval cue). The provision of more retrieval cues, as with increased list structure in a stimulus list, would therefore increase the likelihood of recall. The recognition decision process would be based just on the strength (familiarity) of a stimulus word and its representation in memory. The view of recognition was, therefore, that when subjects were presented with a word they had seen before they would look it up in long term storage and, if it had a strong familiarity (occurrence tag) according to some criterion, recognise it as an old item.

In 1969 Mandler et al. were researching the 'simple' distinction between recall and recognition based on the previously discussed work of Kintsch (1968). They discovered that no simple distinction was possible. They found that recognition was in fact related to degree of organisation, defined as number of categories used in the sorting task. Both in immediate tests and in delayed recognition tests, number of categories and recognition scores were positively correlated, though in no case as strongly as the relationship between number of categories and amount of recall. As a result of their research, Mandler et al. formulated a list of phenomena that an adequate theory of recognition should encompass:

1) First of all, as degree of organisation (or learning) increases, there is an increasing discriminability of old and new words and a decreasing tendency to confuse conceptually related items (primarily involving semantic relations).
2) Specific occurrence tags, that is, those associated with particular lists are, in contrast, unaffected by degree of organisation (or learning).
3) Processes occurring during recall, or mechanisms affecting recall, appear to be more important in determining the recognition of an item rather than sheer presentation of an item. Thus, unrecalled items, though presented, show a

lower level of recognition than recalled items; and, conversely, recalled, though unpresented items (intrusions), show as high a level of recognition as recall items.

4) Much experimental literature suggests that whenever highly organised systems are used, recognition is in fact superior; failures to find effects of organisation are associated with low degrees of organisation (or learning).
5) The effect of organisational factors on recognition increases over time. This suggests that subjects rely more on categorisation and conceptualisation at some time after (e.g. at least a day or two) original presentation of the item.

The apparent contradiction between the initial work of Kintsch (1968) for example, and Mandler et al. (1969) can be resolved by a consideration of the different experimental designs used. This comparison also sheds some light upon the relationship between recognition and recall.

Kintsch gave two groups of subjects a list of 40 words. For the high-structure group the ten most frequent words were selected from each of four categories and arranged in blocks by category. For the low-structure group the ten least frequent words were chosen from each category and were arranged in random order. The words were presented one by one, and half the subjects were given an immediate recall test and half an immediate recognition test. Subjects recalled about 50% more from the high-structure lists than from the low-structure lists.

The recognition test consisted of presenting the 40 old words along with 40 distractor items on a sheet of paper and the subjects were asked to identify the old words. The distractor items were chosen from the same set of words as the learning items. For each category, 20 words were selected (either the most frequent or least frequent ones, depending upon the experimental condition). These were randomly assigned to two classes, learning times or distractors. Thus he assumed that the only way a subject could tell whether an item was old or not was by a judgement of the newness or familiarity of a particular item, and that recognition on the basis of class membership was excluded. The results were clear-cut; there was no significant difference between performance on the high and low structure lists.

There are two basic faults with this experiment. Firstly, Kintsch assumed that subjects used only the particular category level that he imposed on the data for organisational purposes. Secondly, both recall and recognition was immediate. This meant, therefore, that the physical and temporal aspects of the words were strongly available by virtue of these being the predominant type of cues in short term memory (Herriot, 1974). Consequently, recognition could be based solely on 'occurrence tags'. However, this does not mean that recognition after a considerable period of time would be based on the same type of process.

Kintsch concluded that recall and recognition were based on different processes; that recall was dependent on organisational structure, whereas recognition was dependent on 'occurrence tags'. Mandlers experiments (Mandler, 1969b) investigate the effects of lengthening periods of delay before the recognition task. This seems a more valid approach as long term memory is based predominantly upon semantic and organisational codings. A discussion of Mandlers results (Mandler, 1972) provides a plausible insight into the relationship between recognition, recall and memory organisation.

Mandler's findings did not permit a clear distinction between a decision process based on occurrence tags and an independently operating retrieval process based on organisational structures. Both processes seemed to affect recognition memory to varying degrees. There was little doubt that occurrence tagging is a powerful factor in recognition. Such a process would account for much of recognition performance in the laboratory. However, it was clear that organisational factors also enter into recognition memory, and probably more so in everyday usage where information is gained over a longer period.

Mandler suggests that an important way in which organisational processes enter recognition memory depends apparently on weak or decayed occurrence tags. Organisational variables become more important the longer the time interval since presentation. Thus, when subjects are uncertain about the prior occurrence of an item, they are more likely to use retrieval processes and to depend upon relational cues in order to determine prior occurrence. It is intuitively appealing to suggest that the face of someone met just yesterday is recognised on the basis of occurrence information, but that somebody one has not met for years is appropriately recognised only after often extensive retrieval and search involving contexts and categories. In short, occurrence tags pre-empt the recognition process when items are relatively unorganised and recent, but with increasing organisation, as well as with older and weaker tags, organisational processes tend to dominate.

At no time does Mandler try to deny the existence of occurrence information being stored with events or with the organisation of events. What does seem to be the case is that any reasonable theory of adult mental structures must take into account that such occurrence information or tags play a relatively minor role in the production, retrieval, or recall of organised material.

In conclusion, Mandler (1972) cies, "the cumulative evidence and considerations of organisational theory indicate that organisational and retrieval processes play an important part in the recognition of organised material. While occurrence information is obviously coded with input, it is typically overwhelmed by more powerful organisational variables".

From the point of view of the present experimentation it seems reasonable to suppose that yes/no recognition could provide a useful indication of the comparative strengths of cognitive models resulting from the use of various indexes. The strength of a cognitive model would be a reflection of the degree of organisation of the constituent information. However, a suitable delay, between presentation and the recognition task, would have to be decided upon. This would ensure that the processes of retrieval from long term memory were being reflected.

7.6 Decision rules and memory model strength: yes-no recognition (criterion rule)

The most plausible hypothesis about the decision stage of recognition memory is the criterion rule, whereby strength (in terms of the cognitive model) is compared to a criterion. If memory strength is above the criterion, the subject responds "yes" (the item is old or familiar). If it lies below the criterion, the subject responds "no" (the item is new or unfamiliar). This criterion is based upon the strength of coding of an item in memory and the subject's interpretation of this strength. First, therefore, subjects must be sensitive to the codings of previously encountered words, and secondly they must have some inherent criterion level about which words can be classified as either old or new. Figure 7.1 highlights the point that both perceived strength and the decision criterion can vary and also that whether a word is recognised or not depends on where the perceived strength lies in relation to the decision criterion.

Perceived strength of a word would depend on the extent of organisation of the cognitive model of which it was a part. The more organised the model the stronger and more numerous are the associations by which a word is related to other from the same context; in this case the association would be promoted by different indexes. The criterion level, however, is more likely to be affected by subjects' attitudes and motivation with respect to the experimental context.

A rather elegant way to measure the strength of the memory trace for old items under any condition is provided by statistical decision theory. An extensive review is provided by Green and Swets (1966). The statistical decision analysis of recognition memory converts the probabilities of correct and false recognition (hit rate and false alarm rate) into a measure of the strength of the memory trace for the old items.

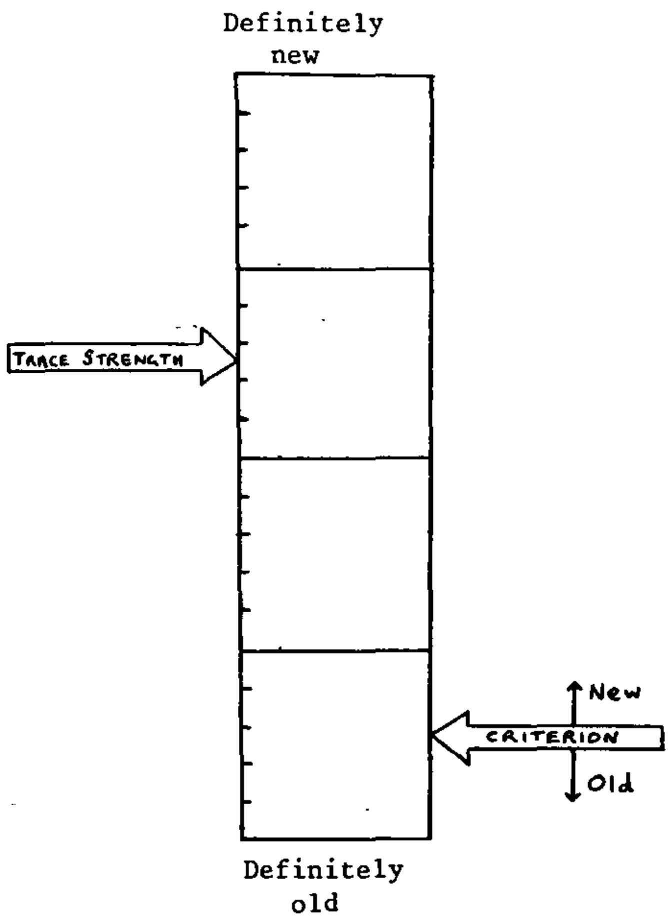


Figure 7.1: Model of factors affecting subject's decision

The present experiment is designed to test the difference in memory model strength between a 2-level and 4-level index. The stronger the memory model the more easily a descriptor from the index should be recognised. A detailed discussion of signal detection theory in relation to memory model strength will provide a basis for the validation of the proposed experimental rationale.

With the incidence of discrete stimuli the signal detection theory model of observer decision making is a very useful technique to apply as it gives a measure of each person's sensitivity in the recognition of words previously encountered. It also gives a measure of the person's criterion level in making of recognition measures in reflecting the strength of a subject's semantic model of information has been previously discussed. Much of this work has used the theory of signal detection as a basis. Therefore, we are justified in using this theory as a basis for comparison of the semantic, or categorical, models formed as a result of using a two or a four level index of descriptors.

Even under constant conditions there is assumed to be substantial variability in the amount of memory strength acquired by information items during learning, and there may be variations at retrieval as well. There may also be variation in the storage phase as a result of different rates of consolidation, decay, or interference for previously presented (old) items. Furthermore, there is variation in the memory strength of items not previously encountered (new items), owing to their similarity or association to old items which contributes to the noise in the retrieval process. All this produces a distribution in the memory strength for both old and new items (see figure 7.2). In this case the memory strength of an item is defined in terms of its strength of association with other items it appeared with, as well as any 'occurrence tags' which may be prevalent, plus the new word interference and level in the system.

It is possible for both distributions to be close enough, in terms of coding strength, to overlap. The area of overlap represents cognitive activity which could either be due to codings of words not specifically encountered previously in the experimental context, or to the extra strength of coding of an old word in comparison to background codings. If the subject sets his criterion of recognition Xc on the decision axis, within the bounds of this area (see figure 7.2), anything on it or to the right of it is recognised as an old word, whilst anything to the left of it is not. As can be seen, however, area A (see figure 7.2) could represent an experimental word plus background noise memory codings (an old word), or just background noise (a new word). Consequently, it is likely that, as well as some old words being recognised, there will also be some new words recognised as old words. By the same argument, in area B there will be some old words not recognised as well as new words not being recognised as presented in the experiment.

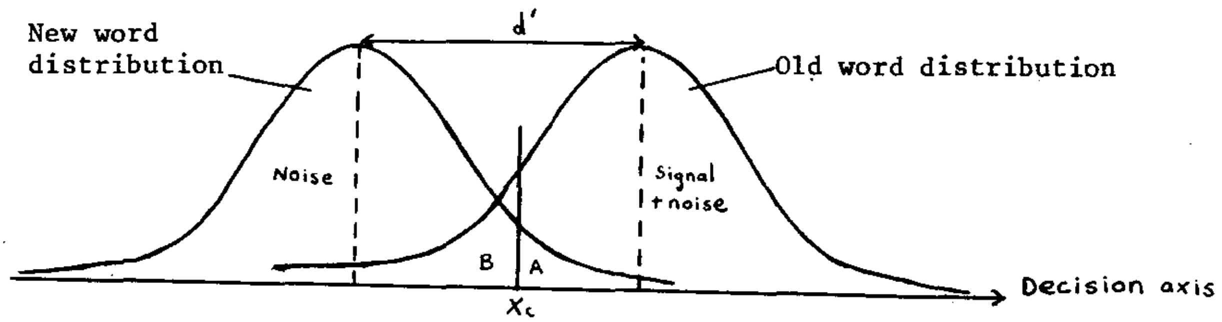


Figure 7.2: Diagram of the signal detection theory model showing the sensitivity measure, d', and the decision criterion, Xc

The further apart these two distributions the bigger d' is (see figure 7.2) and the smaller the number of old words not being recognised and new words being recognised as old. These errors will disappear if the distributions are separate and do not overlap. d' is a measure of the sensitivity of the subject to old words and is independent of his criterion of recognition. Area B corresponds to a Type 1 error in statistics, whereas Area A corresponds to a Type 11 error. The four types of decision outcomes which can be made in response to the stimulus of an old or a new word can be seen in figure 7.3.

SUBJECT'S DECISION

		Respond yes	Respond no	
ACTUAL SITUATION	Old word	OLD WORD CORRECTLY RECOGNISED Old word recognition rate estimates P(OLD/REC.) 'HIT'	OLD WORD NOT RECOGNISED Old word miss rate estimates P(OLD/MISS) 'MISS'	P(OLD/REC.) +P(OLD/MISS)=1
	New word	NEW WORD INCORRECTLY RECOGNISED New word recognition rate estimates P(NEW/REC.) 'FALSE ALARM'	NEW WORD REJECTED New word rejection rate estimates P(NEW/REJ.) 'CORRECT REJECTION'	P(NEW/REC.) +P(NEW/REJ.)=1

Figure 7.3: The four possible outcomes of a subject's decision and their conditional probabilities

The probability that the words presented to the subject contained those already seen is P (OLD) where

$$P(OLD) = \frac{\text{no. of old words}}{\text{total no. of words}}$$

An old/rec. results from a decision by the subject that a word has been presented before when it actually was presented previously. P(OLD/REC.) is the conditional probability of this situation; it is also known as the probability of a 'hit'.

A new/rec. results from a decision by the inspector to recognise a word as being presented before when it was not, P(NEW/REC.) being the conditional probability. This type of decision can also be termed a 'false alarm'. The hit rate (HR) and the false alarm rate (FAR) obtained from any sample of words are estimates of the previous conditional probabilities where

$$HF = \frac{\text{Frequency of old/rec.}}{\text{Frequency of old words}}$$

and $$FAR = \frac{\text{Frequency of new/rec.}}{\text{Frequency of new words}}$$

Where these values are known, the values of the two remaining cells in figure 7.3 can be determined. The old/rej. rate, or miss rate (MR), equals 1 - HR. The new/rej. rate, correct rejection rate (CRR), equals 1 - FAR.

Conceptually, the subjects memory of a word may be represented as illustrated in figure 7.4, by a point, y, in a multi-dimensional space, the number of dimensions depending upon the number of possible coding attributes of old words. In this illustrative example the space is three dimensional to illustrate some of the possible coding dimensions, for example, meaning, physical image, and occurrence 'tags'. This is by no means exhaustive and could include other dimensions. Two probability density functions are associated with each point in the space. One is f(y) for old words, which corresponds to the extra memory trace strength plus noise distribution already meantioned, and is a normal distribution of the probabilities associated with various degrees of 'familiarity'. In other words it is the probability that the memory trace, y, was produced by an old word. The same argument applies to the other probability density function f(y) for new words, or the probability that y was due to a word not encountered in the experiment.

It is assumed that the different types of memory coding all contribute to the one old word distribution. It would be interesting to know whether each type of coding has its own distinct distribution and whether it is valid to compound them like this.

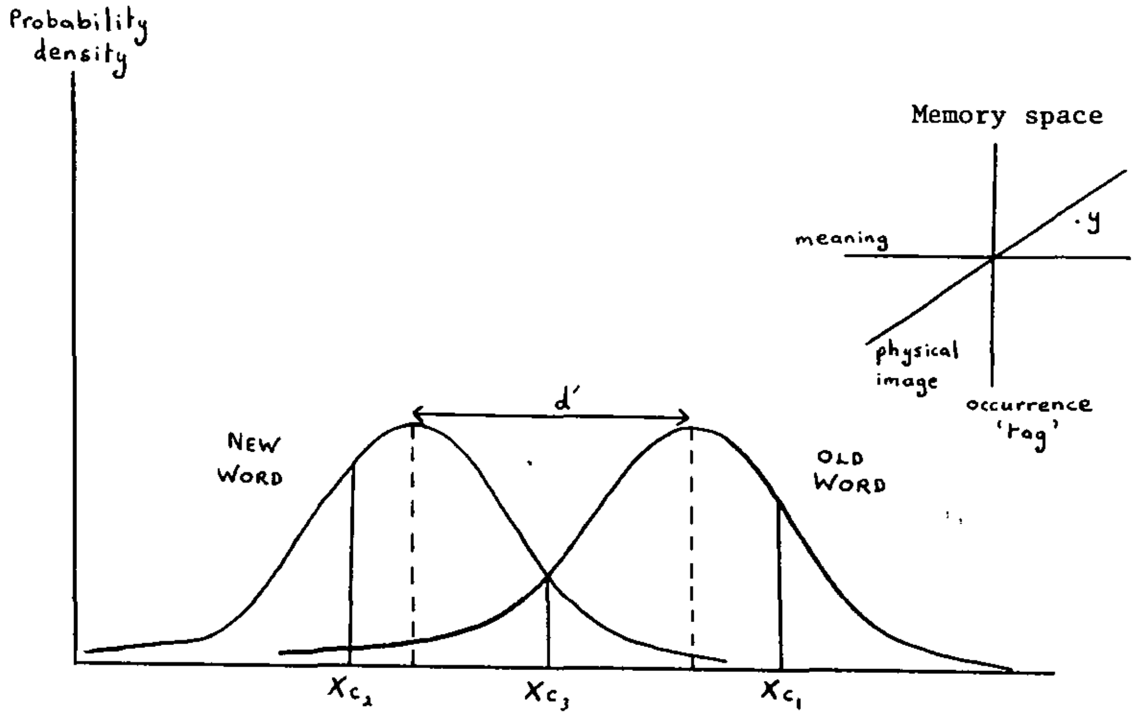


Figure 7.4: A graphical illustration of the basic decision model for the recognition situation.

In figure 7.4 there are three different decision criterion points C1, C2 and C3 along the x axis. C1 represents a subject setting a strict criterion for recognition of a word, in doing this the number of new words recognised as old are cut down but the number of old words not recognised is greatly increased. C2 is the result of a subject with a loose criterion for recognition, the number of old words missed is low, but this is at the expense of many new words being recognised as old. The decision criterion of recognition will depend on the confidence with which the subject reaches a decision. To reduce both new/rec. and old/rej. d', the sensitivity must be increased. Sensitivity will be dependent upon the strength of the memory model which in turn will be dependent on the type of index used. Numerical values can be calculated for the sensitivity and criterion of rejection of the subject, but it must be remembered that two basic assumptions are made:

i) That both distributions are normal (this is usually the case when collecting this type of data from subjects).

ii) That the distributions have equal variance. This can be tested for and the statistical analysis can be changed appropriately.

Green and Swets (1966) point out that these assumptions are made primarily for convenience; the standard normal distribution has unit variance, the mean and variance are independent, and it is often possible to transform variables which are not normally distributed into those which are. The normality assumption can be justified on the basis of statistical theory. According to the Central Limit Theorem, if the subject's observation of words are independent, then the distribution of the sums of the observations of old and new words each approach normality for moderate sized samples of both types of words.

7.6.1 Calculation of Signal Detection Theory Variables

Figure 7.5 shows how estimates of d' and Xc are calculated from obtained HR and FAR scores. The numerical value of Xc is called β.

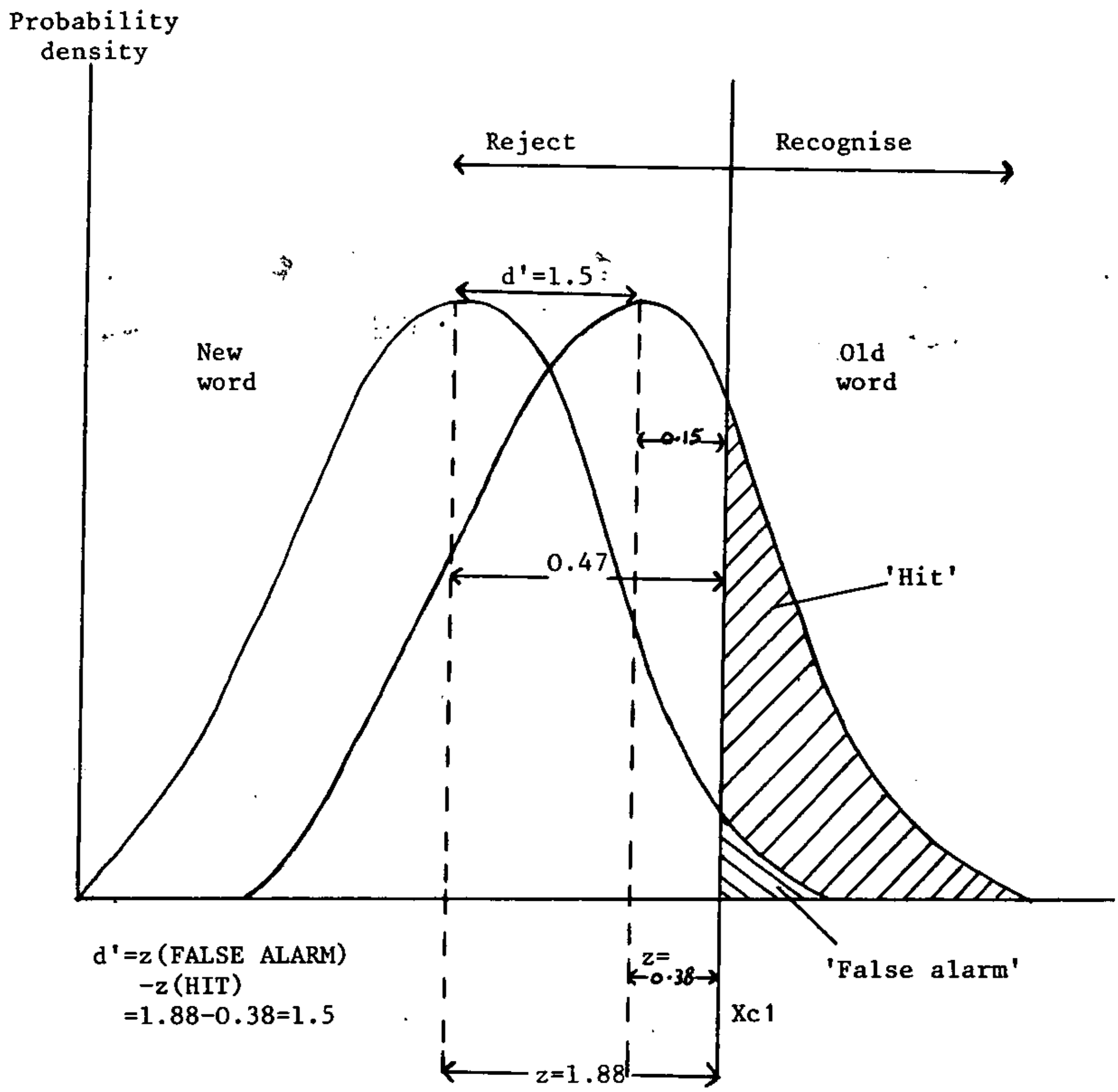
Figure 7.5 illustrates that the subject adopts a strict criterion. Based on the obtained HR = 0.35 and FAR = 0.03, d' can be calculated from the equation

$$d' = Z\,FAR - Z\,HR$$

1. The area under the new word distribution from the mean to X_{c1} is 0.47 (0.5 - 0.03). X_{c1} is thus 1.88 standard deviation (Z) units to the right of the new word mean.

2. Since HR = 0.35, the area under the old word curve from the mean to X_{c1} is 0.15 (0.5 - 0.35). X_{c1} is thus 0.38 Z units to the right of the mean of the old word distribution.

3. By subtraction, 1.88 - 0.38, d' is found to be 1.50.



$$\beta = \frac{\text{P(HIT) at Xc}}{\text{P(FALSE ALARM) at Xc}} = \frac{P(z=0.38)}{P(z=1.88)} = \frac{0.3712}{0.0681} = 5.45$$

<u>Figure 7.5</u>: <u>Calculation of d' and β at a strict criterion of recognition</u>

The value of β is found by placing in ratio the ordinate value of X_{c1} under the old word density function, and the ordinate value at X_{c1} under the new word density function. Figure 7.5 shows that β = 5.45.

As can be seen from figure 7.5 the value of β at X_{c3} where the distributions cross will be 1. The range of values that β can take is sometimes inconvenient if the response bias for a set of criteria is to be represented graphically. Criteria which represent biases toward recognition are restricted to the narrow range $0 < \beta < 1$ while criteria which represent biases toward rejection responses can take any value of $\beta > 1$. This can lead to misinterpretation of the degrees of bias represented by different β values. For instance, $\beta = 2$ represents the same degree of bias towards rejection of words as 'new' as $\beta = 0.5$ represents towards recognition, while, by the same argument, $\beta = 100$ and $\beta = 0.01$ show equal and opposite amounts of bias. To equalise the intervals between degree of response bias and to facilitate graphical representation of results, it is common practice to give bias scores in terms of log β rather than β itself. Figure 7.6 shows that a plot of log β against criterion gives a different, and more meaningful picture of the degree of bias associated with each criterion than does the corresponding plot using β alone. When there is bias towards recognition then log β will be negative. When there is a bias towards non-recognition, or rejection, log β will be positive.

Having explained the technique and the major parameters of the yes/no recognition testing of memory model strength, its place in the experimental rationale can now be appreciated.

7.7 Experimental rationale

In most contemporary computer information storage and retrieval systems it is necessary to enter some appropriate keyword or alphanumeric code to access information. It is usually necessary to access these codes via some paper-based or computer-based index. The present experiment attempts to simulate this in that an index has to be used to ascertain a code number in response to the appearance of a stimulus word on the screen of a micro-computer. The code number is subsequently entered into the computer, which then checks whether the number is the correct one. Consequently, the cognitive model of the task has

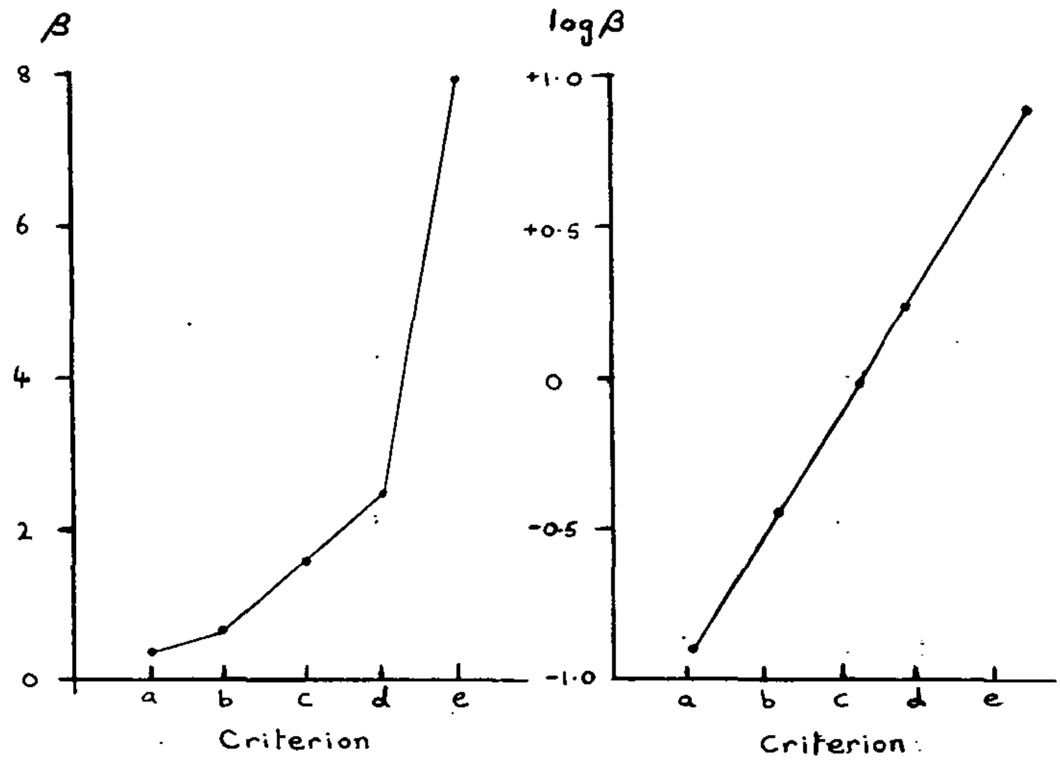


Figure 7.6: Plots of β and log β respectively against criterion

no appreciable spatial cues other than those inherent in the index format, in keeping with interaction with most computer information systems. Also, this serves to remove the spatial factor which might be responsible for people usually only classifying information to two levels.

The other possible reasons, previously discussed, for lack of organisation are easily removed by the nature of the experimental task. Subjects are motivated by being timed in a noval situation, knowing that they are being tested in some way. Occupational time constraints do not apply because they only have the experimental task to concentrate on. Information can be used which is not ideally restricted to a two level classification system and can be easily organised to several levels.

The indexes used are based on those generally used by most people in offices, that is, all levels are listed together on each page and visible at once. This is in contrast to menu-type selection, where a choice of categories from one level of the system is available on each page. A choice, in each case, leads to the categories of another level on some other page.

To prevent bias towards some people and not others it was decided that the indexes should be constructed of the English words associated with many and varied concepts. The source of these words was Roget's Thesaurus, and the indexes refined through pilot work.

The experiment necessarily consisted of four distinct stages:

i) A training period - the importance of this stage was that it should not only familiarise subjects with the experimental procedure, but also should be of sufficient length to eradicate any confounding learning effects.

ii) Main experimental run - here the subjects would use the index to code words in an optimum way as a result of the training period. The differences between using the two-level and multi-level indexes could be validly compared.

iii) Pre-recognition test phase - this stage was important in that it had to be of sufficient length to be sure that recognition was reflecting semantic memory organisation strength. If this period was too short words could be recognised by means of 'occurrence tags'. Consequently, there would be no need to use semantic relations, generated by the two types of index, to either recognise or not recognise a word.

iv) Yes/no recogntion test - here the strength of the cognitive model was tested. Two types of descriptors were presented, those that had been previously coded via an index, and some of similar high level classification but which had not been previously coded. The reasoning behind this was that, if the extra levels of classification of the muti-level index were incorporated into the cognitive model, it would be easier to distinguish words previously coded via the index from similar words, because they would have features in common at a higher general level but not at a specific level of classification. The extra levels would serve to specify the descriptors more accurately.

A matched independent sample design was thought to be more suited to the experiment than a repeated measures design. A repeated measures design would generate too many confounding variables. Independent samples would be more sensitive to differences in cognitive models, providing the matching of subjects was valid.

The measures used in stages i) and ii) were the time taken to code words, and the number of errors made. In stage iv), however, response times and signal detection measures were recorded (i.e. Hits, misses, correct rejections, and false alarms). From these latter measures the main parameter, d' and β, could be calculated. In addition, subject comments were noted concerning the different aspects of the experiment.

The time and error measure were included to represent the general efficiency of the cognitive model concerning index use. Two relationships are possible: first, as time increases errors decrease, and vice versa, indicating a speed-accuracy trade-off and essentially linking efficiency with type of motivation; second, time and errors varying in the same direction, linking efficiency with the strength of the cognitive model.

7.8 Pilot study

The pilot study used ten people to try out the experimental design through the various stages leading to that used in the main study. In addition, many people were consulted on an informal basis about various aspects of the experiment. The objectives of the pilot study were as follows:-

1) To generate a meaningful two-level and multi-level index.
2) To determine the appropriate time period between the task and the subsequent recognition test.
3) To generate appropriate distractor items for use in the recognition test.
4) To develop subject instructions to an optimum level.
5) To iron out any small inconsistencies in the running of the experiment and to ensure that the main experiment went smoothly.

7.9 Indexes used

The indexes used in the experiment were based upon the tabular synopsis of categories of words in the 'University Roget's Thesaurus of Synonyms and Antonyms' (1978). The classification scheme of the thesaurus consisted of five available levels, and by eliminating some of these levels the number could be reduced to two.

Initially in the pilot study both the five- and the two-level indexes were used. However, it was soon apparent from the remarks of the many people consulted, in addition to those used in the pilot experiment, that a combination of the five levels, and the old-fashioned and abstract classification of the words, was rendering the indexes somewhat meaningless. Therefore, the five-level index was reduced to four levels, and the classification scheme was updated to make it more meaningful to subjects. The result was that the classification scheme became more readily apparent and the indexes more easily used. However, some of the words were still being ambiguously interpreted, and so they were replaced with comparable words that could be interpreted unambiguously. The final form of the indexes can be seen on the following seven pages: figure 7.7 contrasts the form of the two-level index and the four-level index; figures 7.8 to 7.13 show, first, the two-level index and, second, the four-level index as presented to the subjects during the experiment.

8. COMPARISON

389. Alteration
699. Unlikeness
362. Resemblance
397. Reproduction
697. Diversity
385. Change
691. Dissimilarity
615. Correspondence
393. Imitation
365. Semblance
612. Interdependence

8. COMPARISON

6. ABSOLUTE

1.	Correlation	-	5. Correspondence
			2. Interdependence
9.	Difference	-	1. Dissimilarity
			9. Unlikeness
			7. Diversity

3. PARTIAL

6.	Similarity	-	2. Resemblance
			5. Semblance
8.	Variation	-	5. Change
			9. Alteration
9.	Copy	-	3. Imitation
			7. Reproduction

Figure 7.7 - A comparison of the form of the two-level index with that of the four-level index

8. COMPARISON

389. Alteration
699. Unlikeness
362. Resemblance
397. Reproduction
697. Diversity
385. Change
691. Dissimilarity
615. Correspondence
393. Imitation
365. Semblance
612. Interdependence

5. DIMENSIONS

822. Elevation
982. Volume
959. Remoteness
828. Altitude
815. Mileage
951. Farness
986. Capacity
985. Magnitude
819. Longitude

Figure 7.8 - Two-level index, page 1

6. **FORM**

672. Level
582. Angle
561. Roundness
584. Bend
678. Smoothness
689. Texture
569. Rotundity
589. Corner
682. Corrugation

2. **MOTION**

821. Thrust
647. Swiftness
144. Upgrowth
814. Repulsion
693. Dawdle
829. Impetus
695. Linger
143. Rising
649. Speed
189. Deflection
148. Climb
813. Rebound
826. Propulsion
181. Drift

Figure 7.9 - Two-level index, page 2

1. <u>HUMAN ATTRIBUTES</u>

613. Grace
139. Regard
829. Depression
143. Scorn
851. Gratification
746. Responsibility
697. Connoisseur
141. Derision
135. Courtesy
749. Liability
614. Elegance
866. Satisfaction
852. Enjoyment
793. Legality
696. Refinement
825. Sadness
796. Justice
868. Serenity
867. Contentedness

Figure 7.10 - Two-level index, page 3

8. COMPARISON

6. ABSOLUTE

1. Correlation	-	5. Correspondence	
		2. Interdependence	
9. Difference	-	1. Dissimilarity	
		9. Unlikeness	
		7. Diversity	

3. PARTIAL

6. Similarity	-	2. Resemblance
		5. Semblance
8. Variation	-	5. Change
		9. Alteration
9. Copy	-	3. Imitation
		7. Reproduction

5. DIMENSIONS

9. GENERAL

5. Distance	-	9. Remoteness
		1. Farness
8. Size	-	5. Magnitude
		2. Volume
		6. Capacity

8. LINEAR

2. Height	-	8. Altitude
		2. Elevation
1. Length	-	9. Longitude
		5. Mileage

Figure 7.11 - Four-level index, page 1

6. FORM

    5. SPECIAL
        6. Circularity - 1. Roundness
                         9. Rotundity

        8. Angularity - 2. Angle
                        4. Bend
                        9. Corner

    6. SUPERFICIAL
        7. Flatness - 8. Smoothness
                      2. Level

        8. Roughness - 2. Corrugation
                       9. Texture

2. MOTION

    6. DEGREES OF MOTION
        4. Velocity - 7. Swiftness
                      9. Speed

        9. Slowness - 3. Dawdle
                      5. Linger

    8. CONJOINED WITH FORCE
        2. Impulse - 6. Propulsion
                     1. Thrust
                     9. Impetus

        1. Recoil - 4. Repulsion
                    3. Rebound

    1. WITH REFERENCE TO DIRECTION
        4. Ascent - 3. Rising
                    4. Upgrowth
                    8. Climb

        8. Deviation - 1. Drift
                       9. Deflection

Figure 7.12 - Four-level index, page 2

1. HUMAN ATTRIBUTES

8. PERSONAL EMOTIONS
    5. Pleasure - 1. Gratification
       2. Enjoyment

    6. Content - 7. Contentedness
       6. Satisfaction
       8. Serenity

    2. Dejection - 9. Depression
       5. Sadness

6. QUALITIES
    1. Beauty - 4. Elegance
       3. Grace

    9. Taste - 6. Refinement
       7. Connoisseur

7. OBLIGATIONS
    4. Duty - 6. Responsibility
       9. Liability

    9. Right - 6. Justice
       3. Legality

1. SENTIMENTS
    3. Respect - 9. Regard
       5. Courtesy

    4. Contempt - 3. Scorn
       1. Derision

Figure 7.13 - Four-level index, page 3

The code numbering scheme employed on the indexes was random so that subjects did not associate the stimulus words with a numerical strategy; also the subject ended up with the same final code number with either index. Each level had an associated part of the code number to ensure that the subjects attended to each classification level. The two-level index had one of the four digits associated with the general level and the other three with each descriptor. The four-level index associated one digit to each level. It was also necessary to require the subject to repeat verbally the word associated with each level when keying in the code number during the task. This made sure that the subjects attended to the word at each level as well as the number; this was only required during the training run.

7.10 Pre-recognition test period

Various pre-recognition test periods were tried. One hour and four hour periods were found to be of insufficient length, because subjects reported having no difficulty recognising old words from new and did not have to think in terms of the semantic structure of the index; this is in line with the 'occurrence tag' theory. A twenty-four hour period which included a night's sleep was found to be satisfactory because subjects reported having to consciously think of semantic relationships to decide whether they had coded a word or not; this was also reflected in the number of false alarms recorded (recognition of a semantically similar word not seen previously).

7.11 Distractor items

Distractor items were chosen from the same highest superordinate level of classification (e.g. Motion) as the experimental descriptors, for the reasons discussed in the rationale (section 7.7). However, care was taken that no distractor item came from the same third level of classification as an experimental descriptor; for example, 'plane' could not be a distractor because it is a member of the 'flatness' third level category already present on the indexes.

Approximately the same number of distractor items (60) were used as there were descriptors on the indexes. The reason for this was that earlier pilot experiments using only 30 distractors gave rise to the suspicion that subjects developed expectations as to the relative proportions of index descriptors and distractors in the recognition test. Therefore, equal proportions were used so that their response decisions would not be biassed either way.

The distractors are listed below under their relative major category headings:

1) Comparison
   - Combination
   - Union
   - Blend
   - Mixture
   - Equality
   - Balance
   - Parity
   - Mismatch
   - Continuity
   - Order
   - Regularity
   - Uniformity
   - Conformity
   - Concurrence
   - Counteraction

2) Dimensions
   - Space
   - Expanse
   - Displacement
   - Boundary
   - Limit
   - Confine
   - Breadth
   - Thickness
   - Interval
   - Depth

3) Form
   - Symmetry
   - Outline
   - Shapeliness
   - Proportion
   - Distortion
   - Deformity
   - Edge
   - Sharpness

4) Motion
   - Journey
   - Locomotion
   - Drive
   - Convergence
   - Departure
   - Start
   - Leap

5) Human attributes

Sensibility
Excitability
Bravery
Rashness
Valor
Expectance
Composure
Friendship
Amity
Brotherhood
Forgiveness
Pardon
Worship
Devotion
Piety
Religion
Pity
Vice

7.12 Subjects used in the experiment

The experiment was based upon an independent sample design, therefore it was important that the subjects in the two samples were matched on the basis of some valid criteria. The experimental task was concerned with classifying English words, some of which had a distinctly scientific context. Rather than matching the subjects ability on some unrelated word definition test, it was thought appropriate to match them in terms of the type of employment that they had taken up. The assumption was that any two people in the same type of employment would have experienced similar backgrounds and have a comparable amount of scientific or artistic bias. Consequently, each subject in one sample had a counterpart in the other sample employed in the same job. There were 12 subjects in each sample comprised of technicians, secretaries, teachers, artists, and research staff of the Human Science Department; a balanced mixture of male and female.

7.13 Subject instructions

The subject instructions were refined in response to subject comments and any misunderstandings noted by the experimenter. Their final form can be seen in appendix 7.1.

7.14 Main experiment

7.14.1 Apparatus

A Commodore (model 3016) computer was used to run the programs which controlled the experimental task and the recognition test; it was also used for the subsequent analysis of the results. Results were output to a printer for hard copy storage as well as being stored on floppy disc. The indexes used to code descriptors have been previously described.

7.14.2 Method

At the beginning of the experiment each subject was asked to sit in a chair in front of the microcomputer. Part A of the instructional procedure was read to them (see appendix 7.1), appropriate for the index, either two or four level, which they were to use. When the experimenter was satisfied that they understood the experimental procedure the program for the first stage of the experiment was run (see appendix 7.2 for EXPA program). The program displayed each of the words from the lowest level of the index in turn on the screen. They were displayed in a random order until all sixty-two were responded to by the subject. In addition appropriate instructions and prompts were displayed. The format was as follows:

```
THE WORD IS : COURTESY

PLEASE ENTER THE CORRECT CODE NUMBER
(RETURN)

THE CODE NUMBER IS        ?
```

Upon the appearance of a word the subject used the index in the prescribed manner (see part A, appendix 7.1) to key in the appropriate code number via a numerical keypad. Subjects using the two level index first keyed in the number associated with the major category and verbally repeated the category name.

They then keyed in the three digit number associated with the stimulus word and pressed the 'return' key. The word was then verbally repeated. Subjects using the four level index first keyed in the number associated with the appropriate major category and repeated its identity. They then followed this procedure for the first subdivision, then the second subdivision, and finally the stimulus word. Upon completion of the four digit sequence they pressed the return key. The computer's internal clock monitored the time period in between each word being displayed and the subject pressing the 'return' key upon completion of the code number entry. The pressing of the 'return' key initiated a sequence where the code number entered by the subject was checked against the correct one stored in an array. If the two matched the computer returned, "CORRECT!" This was followed by "TYPE 'Y' WHEN YOU ARE READY FOR THE NEXT WORD". The time taken and the number input by the subject were stored on separate arrays. When 'Y' was pressed the whole procedure was repeated for the next randomly chosen stimulus word. A mismatch between the stored code number and that input resulted in: "INCORRECT CODE NUMBER, TRY AGAIN!
THE CODE NUMBER IS : ?

The incorrect code number typed in by the subject was stored in an array, as was the error time. The computer was programmed to allow the subjects five errors before they were given the option to type 'Y' for the next word. Entry of the correct code number, before five errors had accumulated, was treated in the same manner as that previously described for correct initial input.

Unpon completion of the first experimental run, the subjects had a rest pause whilst the results were being typed out on a printer.

Prior to undertaking the second experimental run the subjects were read the relevant instructions (part B, appendix 7.1). The procedure was the same as the part A except that they were not required to verbally repeat each category level as they typed the code number into the computer. Upon completion the subjects left and the results were printed out.

Next day, each subject returned at the time corresponding to their arrival the previous day. Again they were seated in front of the micro-computer and read their instructions, this time for the recognition task (see part C, appendix 7.1). When the experimenter was satisfied that the instructions were understood the appropriate program was run (see appendix 7.3 for YORN program).

As before, words were displayed one at a time on the screen. There were one hundred and twenty words altogether, sixty that had been coded the day before and sixty were new, but semantically related, words. The format of the display was as follows:

THE WORD IS : DEFORMITY

WAS THIS ONE OF THE WORDS THAT YOU CHECKED?

PLEASE TYPE 'Y' FOR YES, OR 'N' FOR NO.

In practice, the instructions were redundant because subjects only attended to the stimulus word.

As prescribed the subjects pressed 'Y' or 'N' dependent upon whether they recognised a word as one they had coded or not. Each decision period was timed by the computer and the value entered into one array, the decision was recorded in another. Upon completion the subject left and the results were printed out. No knowledge of results was necessary because this was a one-off recognition task, not a learning exercise.

7.14.3 Generation of results

For the training period and the main experimental run, time and error results were generated by the computer as described in the method. These results were entered into files on a floppy disc for future analysis.

The yes/no recognition test on the computer generated the nature of each decision and also the time taken to make it. The former were comprised of H (hit), FA (false alarm), M (miss), and CR (correct reject) decisions. As with previous results they were stored in files on a floppy disc. The values of the signal detection parameters were calculated for each subject using a computer program specifically designed for this purpose.

7.15 Analysis of results

7.15.1 Training period

Table 7.1 lists the average response times, for the 12 subjects per position in the order of presentation, resulting from the use of the two-level index as opposed to the four-level during the training period. A graph of these average response times against the serial order of word presentation can be seen in figure 7.7. Table 7.2 contains the error scores which accompanied the use of the two different indexes representing the 12 subjects in each sample.

i) Response times: 2-level vs. 4-level.
The respective variances were not homogeneous ($p > 0.05$) therefore a t-test was invalid.

A Mann-Whitney U test was used to test for significant differences between samples; for large samples the Z-score, and hence the probability of occurrence could be calculated (Seigel, 1056).

$U_1 = 2620.5$ $Z = 3.49$
$U_2 = 1223.5$ $p < 0.05$ (2 tail)
$\therefore$ 2-level index response times were generally significantly shorter than those resulting from use of the 4-level index.

This is confirmed by the learning curves in figure 7.7.

2-level				4-level			
1	30.14	32	17.88	1	45.58	32	17.23
2	22.42	33	15.82	2	26.5	33	14.85
3	19.02	34	14.59	3	30.05	34	13.72
4	16.75	35	12.25	4	22.07	35	16.42
5	21.29	36	12.74	5	21.18	36	14.76
6	15.49	37	15.27	6	17.58	37	13.63
7	17.8	38	13.93	7	20.99	38	15.06
8	17.15	39	12.21	8	18.5	39	18.29
9	12.99	40	15.02	9	16.54	40	15.94
10	16.5	41	17.86	10	17.51	41	16.29
11	18.69	42	12.02	11	21.59	42	16.65
12	16.73	43	12.33	12	18.15	43	17.74
13	15.62	44	11.53	13	16.81	44	15.97
14	15.44	45	11.63	14	17.34	45	16.83
15	21.41	46	12.75	15	17.38	46	13.57
16	16.47	47	14.65	16	14.72	47	14.42
17	17.66	48	15.25	17	18.09	48	14.53
18	15.43	49	11.3	18	18.16	49	13.87
19	14.51	50	12.15	19	15.42	50	15.11
20	17.19	51	12.7	20	18.42	51	15.11
21	17.9	52	14.46	21	16.6	52	15.86
22	19.94	53	14.16	22	20.55	53	16.01
23	14.05	54	12.62	23	18.81	54	15.48
24	15.02	55	11.81	24	19.88	55	15.91
25	14.12	56	12.63	25	14.29	56	14.78
26	12.92	57	10.48	26	16.74	57	15.61
27	15.39	58	12.28	27	19.5	58	14.89
28	12.54	59	10.6	28	16.88	59	12.05
29	17.24	60	12.35	29	16.27	60	13.73
30	14.53	61	13.21	30	17.43	61	13.01
31	15.22	62	18.99	31	16.74	62	13.9

	2-level	4-level
S1	0	1
S2	5	4
S3	3	3
S4	0	4
S5	1	2
S6	1	5
S7	0	2
S8	1	7
S9	2	5
S10	0	2
S11	2	7
S12	2	2
Σx	17	44

Table 7.2. Error scores for index use during the training period.

Table 7.1. Training period response times, averaged for 12 subjects, per position in order of presentation.

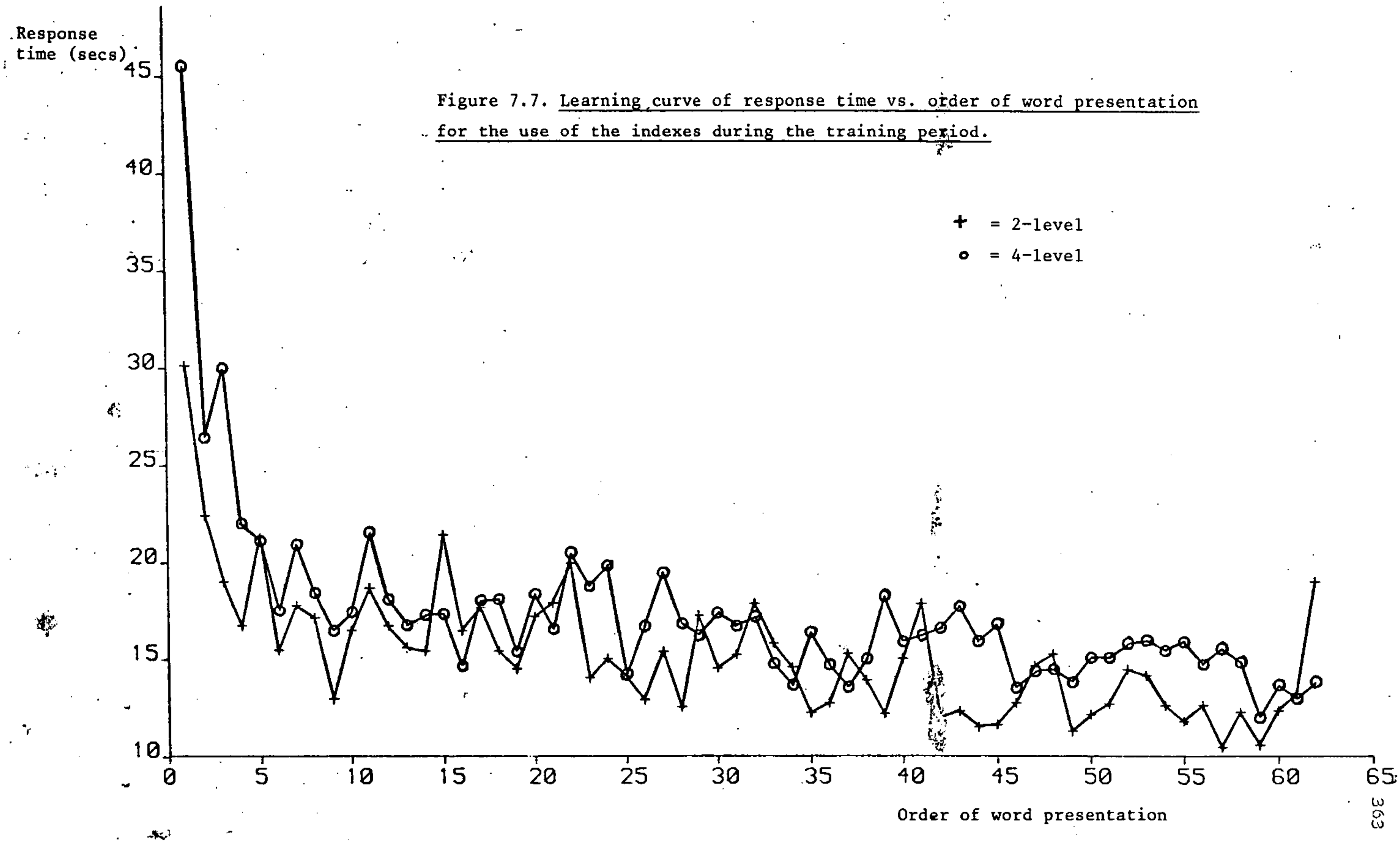


Figure 7.7. Learning curve of response time vs. order of word presentation for the use of the indexes during the training period.

ii) Errors: 2-level vs. 4-level
Mann-Whitney U test.
$U_1 = 117.5$ $U_2 = 26.5$
∴ significantly fewer errors are committed using a 2-level index as opposed to a 4-level.

7.15.2 Main experimental run

Table 7.3 lists average response times according to order of presentation (as in table 7.1). Table 7.4 contains the associated error scores.

i) Response times: 2-level vs. 4-level
Variances not homogeneous ($p > 0.05$)
A Mann-Whitney U test was used.
$U_1 = 2513$ $Z = 2.953$
$U_2 = 1331$ $p < 0.05$ (2 tail)

∴ 2-level index response times were generally significantly shorter than those resulting from use of the 4-level index.

ii) Errors: 2-level vs. 4-level.
Mann-Whitney U test.
$U_1 = 96$ $U_2 = 48$

∴ there was no significant difference in the number of errors committed during the use of the 2-level and 4-level index.

7.15.3 Types of errors

The type and frequency of errors using the two types of indexes are shown in Table 7.5. Keying errors refer to the pressing of the wrong key on the computer's numerical keyboard. Translation errors refer to the misinterpretation of the particular index.

2-level				4-level			
1	9.18	32	9.09	1	10.03	32	10.15
2	9.81	33	11.49	2	9.49	33	11.22
3	8.39	34	8.95	3	9	34	10.04
4	9.03	35	8.23	4	9.57	35	8.71
5	9.01	36	9.64	5	11.43	36	13.56
6	9.79	37	19.28	6	11.21	37	12.9
7	9.65	38	13.56	7	11.53	38	11.84
8	9.06	39	8.59	8	10.92	39	10.5
9	9.18	40	8.88	9	11.23	40	8.92
10	10.44	41	8.64	10	11.01	41	9.45
11	12.51	42	8.36	11	12.19	42	11.39
12	14.31	43	10.55	12	12.15	43	10.96
13	10	44	6.48	13	9.48	44	6.95
14	9.9	45	9.04	14	12.43	45	8.68
15	8.08	46	8.18	15	9.48	46	9.01
16	10.26	47	9.04	16	11.2	47	9.17
17	9.77	48	10.46	17	10.35	48	9.96
18	10.14	49	8.74	18	9.46	49	9.36
19	8.57	50	7.88	19	10.44	50	10.27
20	9.68	51	8.17	20	8.65	51	8.48
21	8.63	52	7.41	21	9.24	52	9.48
22	10.22	53	10.34	22	9.32	53	9.57
23	9.49	54	8.03	23	8.98	54	9.62
24	8.29	55	7.39	24	8.12	55	8.97
25	9.46	56	10.46	25	11.94	56	9.84
26	9.92	57	9.01	26	13.29	57	9.57
27	10.8	58	9.8	27	9.04	58	11.15
28	10.7	59	7.99	28	8.93	59	9.25
29	9.34	60	7.96	29	10.53	60	9.17
30	10.08	61	7.56	30	8.22	61	11.12
31	9.87	62	8.48	31	11.27	62	9.01

Table 7.3. Main experimental response times, averaged for 12 subjects, per position in order of presentation.

	2-level	4-level
S1	0	3
S2	1	2
S3	2	1
S4	0	5
S5	0	0
S6	0	2
S7	0	1
S8	2	7
S9	3	1
S10	0	1
S11	0	2
S12	4	0
$\sum x$	12	25

Table 7.4. Error scores for index use during the experimental period.

Part of experiment	Type of errors committed	2-level	4-level
Training	Keying	7	2
	Translation	12	37
Experimental	Keying	4	6
	Translation	6	12

Table 7.5: Type and frequency of errors committed during the different experimental periods by 2- and 4-level index users

Keying errors were in the minority and did not seem to be dependent on the particular index used. This is to be expected, because once a number has been translated from the index the keying of it into the computer is just a matter of manual dexterity.

The majority of errors occurred due to mis-translation of the indexes. Errors through the use of the 2-level index were mainly of the form of locating a word and then reading the three-digit number of an adjacent word; or mixing up digits from adjacent words. There were less errors in the experimental run by virtue of the learning taking place during the training period. When using the 4-level index, subjects seemed initially to find it very difficult to differentiate the appropriate levels connecting the general category with the displayed word. They either missed a level altogether, and hence the number, or located an inappropriate level, thus interpreting the wrong number. It was very noticeable that it was the perceptual configuration which was causing the trouble, and this is reflected by the much greater number of translation errors in the training run compared to the corresponding period of 2-level index use.

There was a decrease in translation errors in the experimental run, but the total was still appreciably higher than that of subjects using the 2-level index.

7.15.4 Subjective comments on using the indexes

i) Training Periods:

With the 2-level index all subjects reported that, although they were aware of the general headings, they initially had to scan the words on the right-hand side to establish connections and comprehend the classification scheme. This was also the case with the 4-level index, where extra difficulty was experienced in trying to trace the appropriate path through the four levels. As time progressed and subjects began to become familiar with the index they could, with some words, turn to the correct page and locate the appropriate general category section.

The usual strategy with the 2-level index was to locate the appropriate general category descriptor and then scan through the associate group to find the required stimulus word. The general category number would then be typed in, followed by the stimulus word number.

There were two strategies evident with the four-level index, each used by approximately 50% of the subjects. The first involved locating the general category and then the stimulus word. Subjects would then trace the appropriate path between them entering numbers into the computer accordingly. The second was characterised by subjects locating the appropriate general category, then the appropriate next level of classification, and so on, entering the appropriate number at each stage.

As learning progressed the subjects became more proficient (this is reflected in the learning curves in section 7.15.1). It was of importance to note, however, that subjects had to revert to scanning the index with words whose associations were not as obvious as the others.

ii) Experimental period:

This section was characterised by the same kind of strategies as the previous one, except that subjects were more proficient. However, because subjects were no longer required to repeat all the descriptors aloud most subjects (10) said that they paid scant attention to the middle two levels of the 4-level index. They tended to follow a spatial pattern from general level to stimulus word just attending to the appropriate number at each level.

7.15.5 <u>The yes/no recognition test</u>

i) Decision times: 2-level vs. 4-level

Table 7.6 lists the decision times per position in the word presentation order, averaged across the twelve subjects in each sample.

A test for homogeneity of variance justified the use of a students t-test on the data ($F = 1.12$, $p > 0.05$)

$\bar{x}_1 = 2.170$ secs $\quad t = 3.167 \quad df = 238$

$\bar{x}_2 = 1.896$ secs $\quad p < 0.05$

Therefore, the average decision times for subjects who had used the 2-level index were significantly longer than those of subjects who had used the 4-level index.

ii) Nature of the decisions and signal detection parameters:

A computer program was used to calculate the various parameters of the signal detection theory outlined in section 7.6. The results for the 2-level and 4-level index users can be seen in table 7.7; listed are % hit rate, % false alarms, D^1, $Ln\beta$.

Table 7.6. Decision times, averaged across the 12 subjects, for the yes/no recognition test for each of the words presented.

2-level

1	2.63	41	3.99	81	3.23
2	2.04	42	1.79	82	2.99
3	1.35	43	3.23	83	2.48
4	2.29	44	3.11	84	2.06
5	1.94	45	2.15	85	2.7
6	1.53	46	2.06	86	2.78
7	1.43	47	1.24	87	2.26
8	2.71	48	1.85	88	1.23
9	2.39	49	1.23	89	2.16
10	2.34	50	1.48	90	2.4
11	1.73	51	3.95	91	3.26
12	1.48	52	2.01	92	2.66
13	1.4	53	1.48	93	2.38
14	1.3	54	1.59	94	1.99
15	2.93	55	1.1	95	2.31
16	3	56	.99	96	2.22
17	1.49	57	1.56	97	2.59
18	1.4	58	2.13	98	2.83
19	1.19	59	1.68	99	2.63
20	1.73	60	2.07	100	2.53
21	2.52	61	2.84	101	2.24
22	1.52	62	1.5	102	3.62
23	1.83	63	2.57	103	2.92
24	1.61	64	1.97	104	2.37
25	1.44	65	2.2	105	1.88
26	1.76	66	3.15	106	2.12
27	1.8	67	2.53	107	1.52
28	2.06	68	2.76	108	3.21
29	3.18	69	3.11	109	1.99
30	2.46	70	2.38	110	2.31
31	1.34	71	3.22	111	1.3
32	1.7	72	3.54	112	1.21
33	2.65	73	2.82	113	2.6
34	1.65	74	2.16	114	2.94
35	1.15	75	2.17	115	2.03
36	2.28	76	3.84	116	2.82
37	2.01	77	1.55	117	1.18
38	1.57	78	2.78	118	1.39
39	1.12	79	1.46	119	1.68
40	1.96	80	2.82	120	1.4

4-level

1	1.31	41	2.58	81	3.69
2	2.37	42	1.85	82	2.35
3	1.25	43	2.08	83	1.99
4	1.59	44	2.31	84	1.9
5	1.36	45	1.72	85	2.03
6	1.27	46	1.77	86	2.93
7	1.54	47	1.27	87	2.48
8	3.45	48	1.52	88	1.63
9	3.06	49	1.51	89	1.39
10	2.08	50	1.11	90	1.62
11	1.71	51	1.6	91	3.67
12	2.58	52	1.64	92	1.66
13	1.62	53	1.33	93	1.87
14	1.97	54	1.21	94	1.35
15	1.73	55	1.3	95	2.01
16	1.84	56	.98	96	1.54
17	1.03	57	1.55	97	1.57
18	1.3	58	1.34	98	2.24
19	1.25	59	1.84	99	2.97
20	1.58	60	1.97	100	1.94
21	1.06	61	2.69	101	1.47
22	1.82	62	1.23	102	2.79
23	1.28	63	1.96	103	2.63
24	1.44	64	1.41	104	1.78
25	2.45	65	2.7	105	1.67
26	1.38	66	1.91	106	1.61
27	1.19	67	1.68	107	1.5
28	2.19	68	1.33	108	2.17
29	2.81	69	2.62	109	2.9
30	3.3	70	1.94	110	2.4
31	1.38	71	2.23	111	1.59
32	1.14	72	2.75	112	1.18
33	3.17	73	3.39	113	1.38
34	2.22	74	1.94	114	1.88
35	1.22	75	1.43	115	1.27
36	1.64	76	3.7	116	2.03
37	1.37	77	1.98	117	1.28
38	1.09	78	3.49	118	1.22
39	1.41	79	2.38	119	2.27
40	1.73	80	2.03	120	1.16

	2-level index				4-level index			
	%HR	%FA	D'	Ln	%HR	%FA	D'	Ln
S1	90.00	45.00	3.35	-1.47	90.00	8.33	4.32	0.18
S2	91.67	36.67	3.59	-1.45	91.67	13.33	4.18	-0.46
S3	91.67	31.67	3.69	-1.31	80.00	26.67	3.34	-0.28
S4	78.33	3.33	4.28	1.83	66.67	11.67	3.46	1.02
S5	73.33	11.67	3.62	0.80	98.33	48.33	4.02	-3.32
S6	91.67	21.67	3.92	-0.94	93.33	20.00	4.07	-1.08
S7	93.33	20.00	4.07	-1.08	86.67	13.33	3.96	0.00
S8	85.00	8.33	4.11	0.58	90.00	21.67	3.84	-0.76
S9	76.67	13.33	3.64	0.55	90.00	41.67	3.41	-1.40
S10	90.00	26.67	3.71	-0.96	88.33	16.67	3.91	-0.35
S11	76.67	20.00	3.42	0.15	88.33	23.33	3.72	-0.68
S12	93.33	38.33	3.66	-1.72	85.00	10.00	4.03	0.40
$\bar{x}$	85.97	23.06	3.75	-0.42	87.36	21.25	3.85	-0.56

Table 7.7. Values for signal detection theory parameters calculated for each subject

Tests for homogeneity of variance showed no significant difference at the 5% level for the comparison of corresponding results for the two levels of index for each parameter. It was therefore valid to use a student's t-test. The results of the analysis are as follows:

% HR:	2 vs. 4,	$t = 0.44$ NS ($p > 0.05$)
% FA:	2 vs. 4,	$t = 0.35$ NS ($p > 0.05$)
D^1:	2 vs. 4,	$t = 0.81$ NS ($p > 0.05$)
$Ln\beta$:	2 vs. 4,	$t = 0.31$ NS ($p > 0.05$)

Therefore, there was no significant difference in the accuracy of decision, as to whether a word had been previously coded, between subjects who had used the 2-level index and those who had used 4-level index.

7.15.6 <u>Comparison of decision times for Hit, FA, Miss, and CR</u>

The average decision times per decision parameter are tested for each subject in table 7.8. The analysis (using Omnibus) is as follows:

i) 2 - vs 4-level:

Hit :	NS	($p > 0.05$)
Miss :	NS	($p > 0.05$)
CR :	NS	($p > 0.05$)
FA :	NS	($p > 0.05$)

ii) 2-level:

Hit vs. Miss:	Hit < Miss ($p < 0.001$)
CR vs. FA :	NS though CR < FA
Hit vs. CR :	Hit < CR ($p < 0.05$)
Miss vs. FA :	NS though Miss > FA
Hit vs. FA :	Hit < FA ($p < 0.001$)
Miss vs. CR :	Miss CR ($p < 0.05$)

	2-level index				4-level index			
	HIT	MISS	CR	FA	HIT	MISS	CR	FA
S1	1.11	1.51	1.32	1.70	1.41	1.77	1.31	1.60
S2	1.88	2.60	2.60	2.10	2.41	5.93	2.39	3.06
S3	1.77	7.79	2.31	3.12	1.51	2.50	2.01	2.47
S4	1.45	2.05	1.25	3.61	1.25	1.99	1.46	1.44
S5	3.07	6.83	3.63	6.11	1.13	2.53	1.83	1.34
S6	1.33	3.63	1.74	2.52	2.73	7.29	4.71	4.55
S7	1.23	3.15	2.23	1.63	1.96	4.80	3.46	2.74
S8	1.56	3.17	1.88	2.05	9.23	1.98	1.07	1.75
S9	1.34	2.99	2.57	2.67	2.03	2.66	2.26	2.64
S10	1.70	3.47	2.23	2.71	1.22	2.83	1.23	1.14
S11	1.65	2.21	2.17	2.39	0.87	1.31	1.04	0.94
S12	1.91	6.30	3.58	4.65	1.19	2.20	1.82	1.87
$\bar{x}$	1.67	3.80	2.29	2.94	2.24	3.15	2.07	2.13

Table 7.8. Decision times for the four decision parameters.

iii) 4-level:

Hit vs. Miss	:	Hit $<$ Miss ($p < 0.005$)
CR vs. FA	:	NS though CR $<$ FA
Hit vs. CR	:	NS though H $<$ CR
Miss vs. FA	:	NS though Miss $>$ FA
Hit vs. FA	:	NS though H $<$ FA
Miss vs. CR	:	Miss $>$ CR ($p > 0.05$)

The results in i) show that there is no significant difference in the average times of the four different decisions between subjects who used the 2- and 4-level indexes. Comparison of the four types of decision for both groups of subjects, ii) and iii), consistently shows two significant differences; that the decision times to make a 'hit' and a 'correct reject' are both significantly faster than making a 'miss'. Although significant differences amongst the other comparisons are either absent or inconsistent across the two groups of subjects, the trends shown suggest that the making of a correct decision is faster than making an incorrect decision. Also, a general assessment leads one to suggest that a possible sequence of decisions, in order of increasing decision time, is that Hit, CR, FA, Miss. This is confirmed by the order of the means in the 2-level results in table 7.8, and would be confirmed for the 4-level results if it was not for the single long average decision time for a list by S8; without this result the average $\bar{x}$ is 1.61 secs.

7.15.7 Subjects comments about decisions

All the subjects when questioned reported two general strategies for making a decision as to whether a word had been previously coded. They either had a 'gut reaction' that they had or had not seen it before, or they tried to remember the semantic levels of classification from the particular index. The 'gut reaction' implies some judgement of familiarity of each word. On the other hand, the alternative seems to have been some kind of associative strategy where words were consciously related to their superordinate levels of classification.

However, in the latter case subjects reported that the strong association was with the general category; the 4-level users reported that they could not easily remember, if at all, the intervening classification levels.

7.16 Discussion

7.16.1 Training and experimental periods

The results showed (section 7.15.1) that during the initial training period the 2-level index was significantly easier to use, in terms of response time and errors, than the 4-level index: It is also evident from the learning curves (figure 7.7) that a greater amount of initial learning took place with the 4-level index but within 5 word presentations the coding and keying time per word had stabilised to an average value that was slightly above that of the subjects using the 2-level index. However, we should note that part of the extra response time, associated with the 4-level index, was due to reading aloud the two extra descriptor levels during this period.

The types of errors made when using the 4-level index were predominantly in translating the code number for each word. In conjunction with subject comments, this suggests that subjects were having difficulty in conceptualising the links between the classification levels and that they would often locate the wrong number, thus invalidating the code number. Their main problem seemed to be in keeping tack of where they were in relation to the displayed word and general category descriptor. The significantly lower incidence of translation errors arising from 2-level index use indicates that it was easier to use in terms of establishing the correct conceptual link between levels, and hence the component parts of the code number. Subjects tended to locate the appropriate general category descriptor and then scan the adjacent group of descriptors for the appropriate one.

The results from the main experimental run reflected the same characteristics as during the training run, except that the learning effects had been eradicated. Again, the use of the 2-level index promoted significantly quicker response times and incurred fewer translation errors (though not significantly so) compared to use of the 4-level index. Thus, it seems that the translation of a code number from four levels of classification across a page is conceptually more difficult than from two levels. Moreover, this must be related to the spatial grouping and not the categorical relations; we would expect the extra levels of a 4-level index to confer a distinct advantage with a categorically based location strategy, because the extra levels would serve to define the path of associations more specifically between the top and bottom level.

7.16.2 The yes/no recognition task

There were two types of parameters used to measure performance in the yes/no recognition test: the first reflected the decision times and were a reflection of the efficiency of the memory model in making a decision; the second reflected the accuracy of decision and were concerned with the information upon which the decision was based.

Analysis of the decisions produced two interesting findings: the average decision time in responding to a stimulus word was significantly faster for subjects who used the 4-level index; there was no significant difference concerning the accuracy of the decision between 2-level and 4-level index users. The latter results arose from a comparison of % hit rate, % false alarms, sensitivity (d^1), and judgement criteria ($Ln\beta$) between 2- and 4-level index users.

We would expect that if the subjects were using the two extra classification levels of the 4-level index to specify an association between general category and stimulus word, then the results would reflect a greater accuracy of decision and longer decision times. This would be in comparison to the possible 2-level association between general category and stimulus word, where we would expect less accurate but faster decisions; the argument assumes that the subjects reach a decision by following association paths established in memory, the decision time being proportional to the number followed. However, this decision model cannot explain the results obtained, therefore the extra classification levels seem to be redundant in terms of semantic associations; a fact supported by subject comments in section 7.15.7.

If the decision was based purely upon 'occurrence tags' from word presentations, we would expect no difference in the accuracy of decision, and no difference in the decision times. Again, the requirements are not met.

If the differences in decision time are not due to additional semantic association cues, and considering that 'occurrence tags' from the presentation of stimulus words must be the same for both 2- and 4-level index users, we must look for some other facet of the indexes which is different. The obvious feature is that of the spatial layout of the indexes. From their comments it was evident that the subjects' dominant association, in both 2- and 4-level index use, was between the general category descriptor and stimulus word, and that they traced a 'path' between them. The 4-level index has fairly distinct 'paths' between the general category descriptor and the stimulus word, each 'path' having a characteristic 'shape'. The 2-level index, on the other hand has a block of stimulus words adjacent to each general category descriptor. Here, 'paths' are between general descriptor and the block of stimulus words, precluding specific paths to individual words. It is feasible, therefore, that subjects might utilise some internal spatial 'image' of their respective indexes upon which they base their decisions. A more definite 'image' of the association between general category and stimulus word would produce more confidence in that relationship, this resulting in a faster decision time. Alternatively, the characteristic spatial organisation of semantically related descriptors at level 4, the lowest level, of the 4-level index might also strengthen the spatial associations between the highest and lowest levels, 1 and 4; this would still exclude use of the middle two levels, or any other explicit semantic cues (namely, the semantic aspects of the spatially clustered stimulus words in level 4), which would result in an increased decision accuracy. In other words, the splitting up of the blocks of descriptors prevalent at level 2, in the 2-level index, enhances the spatial associations between the general category descriptor and the stimulus word in the respective spatial memory model. Again, this would promote a more definite 'image' of the association between general category descriptor and stimulus word; this would produce more confidence in the relationship and hence a faster decision time. In conclusion we should note, however, that the actual answer may be a combination of the previous two explanations.

Results in table 7.8 show that a correct decision of either yes or no was generally faster than an incorrect decision. Wason's (1959) theory of negation in reasoning provides a possible explanation. A subject first tries to verify a positive hypothesis and, if unsuccessful, then verifies the negative counterpart. Therefore, if a subject can make an immediate positive judgement, either yes or no, then decision times are shorter. If a subject is unsure and has to verify both alternatives, the decision time will be extended. Consequently, we can see that our confidence in a decision can decrease the time spent making it.

However there is an inconsistency which needs to be explained. The average decision time of the twelve subjects for each word presented (table 7.6) was faster for the 4-level index users. But when average decision times for each of the twelve subjects were listed for each of the four possible decisions (table 7.8), there was no significant difference between corresponding 2- and 4-level values. The main reason for the latter is that each subject's one hundred and twenty decision times are reduced to just four averages representing each type of decision. Hence, the variance which accounted for significant difference in table 7.6 has been effectively removed to examine the relative average times of each subjects four decision types.

Summarising: although the 4-level index did not produce a stronger semantic, or categorical model, and hence a greater accuracy of decision, there was evidence that it produced a better spatial 'image', and hence decreased the decision time for recognition of stimulus words. Incorrect decisions, taking a longer time, could be based upon a less strong spatial 'image' between associated words.

7.16.3 Conclusions

In keeping with the experimental aims and basic considerations of the experiment, the following conclusions can be drawn:

1) The 2-level index was easier to use than the 4-level index.

2) The categorical memory model arising from the use of the 4-level index was no more extensive than that arising from the 2-level index; only the highest and lowest levels were incorporated from both.

3) There was evidence that a superior spatial model arose from the use of the 4- as opposed to the 2-level index.

4) As only two levels of the 4-level index were incorporated into the categorical memory model, it would seem that people naturally conceptualise the categorical structure of information to two levels, when not required to do otherwise.

With the type of index used in this experiment, the conceptual adequacy of two levels of classification, as opposed to four, is demonstrated. Consequently, in the office, there may be little point in elaborate indexing when two levels will suffice. This is especially important in view of time and motivation constraints, the usual functional conception of information, and the well-developed, innate spatial awareness of most human filing system users (see Chapter 3).

8. DISCUSSION

8.1 Introduction

In the introduction (Chapter 1) the aim of the research was described as, "... to provide an understanding of some of the conceptual processes and models involved in information storage and retrieval". Furthermore, the context to which the findings relate was described as one of making recommendations which could contribute to the future development of computerised information storage and retrieval systems, the design being specific to the non-computer professional in an office environment. However, this context, although providing a general orientation for our assessment of findings, does not provide a specific framework for discussion of their relevance and their implications, either for the design of computer information systems at present or for related work that might be done in the future. To a certain extent this provision is catered for in the literature survey (Chapter 2); but the concern there was with setting the scene for the subsequent experiments, although conceptual needs relating to man-computer interaction were also discussed.

The framework required for this discussion should be in terms of what is acceptable to the non-computer professional user of computer-based information. At the same time it should be able to incorporate the relevant work of other researchers. Such a framework is provided by Eason et al. (MICA Survey, 1974) in terms of their 'user acceptability' guidelines.

8.2 User acceptability

The MICA Survey (Man-computer Interaction in Commercial Applications) (Eason et al., 1974) was aimed at investigating the problems which computer users, who are not computer experts, have when they endeavour to use the computer to help them in their work. The objective was to develop a behavioural model of the non-computer specialist as a computer user; the underlying hypothesis was that there would be regularities in the response of similar types of computer user which would transcend the systems and organisations concerned.

A number of guidelines, concerning the needs of the naive computer user which had to be fulfilled to render the system 'acceptable', arose from the survey. These are as follows:

i) 'Task Fit'

The system must provide the information, and/or the information processing facilities, that the user needs to perform his task. The functions that a person needs to undertake to complete their allotted task(s) must be catered for by the system in terms of its operations and procedures, the language used, and the time base of interaction (see Chapter 2, section 2.2.1).

ii) 'Ease of Use'

The means by which the user operates the system must be acceptable to him. Four aspects of the man-computer link were identified as being important contributors to the ease of use of a system: the physical and psychological characteristics of the man, and the hardware and software aspects of the computer. A close match between the user characteristics and computer characteristics is needed to ensure maximum 'ease of use'. The matches are as follows:

a) The hardware of the computer must match the physical aspects of the man, e.g. the size, travel and operating pressure of the keys must suit the strength and size of the human finger.

b) The hardware of the computer must also suit the psychological characteristics of the man, e.g. the layout of the keyboard should be easily remembered and not overload the users' short term memory.

c) The software of the computer system should match the physical characteristics of the man, e.g. the refresh rate of characters on a VDU should be such that the persistence of his retinal image prevents flicker being perceived.

d) The software of the computer system should also suit the psychological capabilities of the user, e.g. the structure of a database should be logical to the user and consistent with his cognitive structure.

However, in practice these distinctions are much more fuzzy: first, the user is constrained to varying degrees along the systems software - applications software continuum (operating systems - programs), so the amount of user control varies with his proficiency; secondly, the difference between hardware and software is becoming somewhat blurred, for example, pre-wired programs might be considered software or hardware.

The compatibility between the characteristics of the user and computer determines the user's attitudes towards and conception of computer use, and hence is related to his 'ease of use' judgement.

iii) 'User support'

An important issue arising from the survey, which had not been fully appreciated up to that point, was the extent to which users needed help to make effective use of the system. Two types of support were identified, documentary (e.g. manuals), and human (e.g. the 'local expert').

In designing for non-computer professional users, user support mechanisms are very important, especially with discretionary users, to ensure that they can efficiently use the computer. In practice, however, some user support facilities are as confusing as the computer system itself.

iv) Indirect consequences

Included here are any side effects of computer system use which affect the nature of a person's job or career. Indirect consequences can be positive (e.g. promotion), or negative (loss of status or power).

For the purpose of our discussion framework the first three aspects of user acceptability, namely 'task fit', 'ease of use', and 'user support' are most important. However, we should bear in mind the fact that insufficient attention to these first three aspects can result in negative indirect consequences. We should also note that all these guidelines are somewhat inter-dependent; for instance, it is possible to have a system that is easy to use but not appropriate to the user's tasks. Alternatively, it is possible to have a complex system which could potentially fulfil all the user's task functions, but it may be impossible to use due to its complexity and lack of user support.

Now that we have defined our discussion framework we can discuss the implications of the results from the preceding experiments. The suggested implications of the results should be considered as an attempt to enhance 'task fit', and/or 'ease of use', and/or 'user support'. Their implementation as design features into computer-based information storage and retrieval systems should help to improve user acceptability and reduce the possibility of negative indirect consequences.

8.3 Implications of the research in terms of user acceptability

The previous chapters, in which relevant literature, field survey and experimental work have been discussed, will be reviewed separately in the order in which they are written.

8.3.1 The literature survey

In Chapter 2 we reviewed relevant literature pertaining to the development of concepts relevant to human information storage and retrieval behaviour; in particular, the representation of these concepts in memory is discussed.

In section 2.8.4 of the literature survey, a number of implications concerning the different types of information storage in memory were discussed in terms of man-computer interaction.

Organisation of the database in terms of human semantic memory (section 2.8.4) was considered advantageous in aiding human conception of the stored information relations. Knowledge structures are being used at present for this purpose, for example, the MYCIN program for aiding diagnosis of fungal infections (van Melle, 1978).

The use of imagery (section 2.5.2) as a means of information communication would seem to have positive advantages, considering its use in mediating the memory storage of verbal concepts. Image analogues have been found useful in, for instance, giving feedback on the state of the system. An example is the countdown clock used by Spence (1976) to show the length of processing time left in certain computer operations. We also know intuitively that pictures and graphs can convey relational concepts almost instantaneously, perhaps due to parallel processing. Furthermore, overt spatial organisation can also aid the formation of an 'image' of an information display (see formatting and coding, section 2.2.2 and also all experiments).

Finally, we have a fairly short-lived episodic memory (section 2.5.3), whereby the temporal sequence of events can be stored, which might be exploited in any short term computer storage.

However, a note of caution is necessary. We know much of human information processes in the context of non-computer tasks, such as using language, but little specifically in terms of interaction with computers. We must not assume that the wealth of laboratory research is necessarily relevant; rather, we should undertake similar experimental investigation into psychological processes specifically within the context of man-computer interaction.

The most important point arising (section 2.8.1) was that the storage and retrieval of concepts by the memory processes is highly organised and usually hierarchical in manner. Furthermore, these processes function according to previously stored strategies, plans, and rules. Therefore, it would seem logical that we should cater for these characteristics when designing computer information systems. We should organise information, operations and procedures, and the language of interaction in such a way that they are compatible with the systematised processes by which humans acquire and interpret information: computer information processing strategies and plans should match those already available to the users; system rules should be logical in terms of human information processing rules (e.g. language); computer-aided problem solving should progress in an easily understood manner according to human problem solving characteristics. Only when these aspects are fulfilled can we be confident that naive-users will be able to exploit computers fully, with a minimum of training. However, as with any form of 'ultimate' answer', retrospect gives rise to reservations. Attempts to model human information processing characteristics have never met with the success that was predicted. A good example is the use of natural language which tends to result in users assuming too much 'intelligence' on the computer's behalf (Fitter, 1979). In reality the computer cannot match the ability of humans to use redundant information to understand context, or their powers of subsequent inference. Therefore, although it seems a good idea to provide 'natural' means of computer interaction, it is probably better to make sure that users are aware of the computer's limitations (Fitter, 1979).

8.3.2 The survey of office filing systems

The findings of the survey (Chapter 3) were divided into three sections between which there was considerable overlap: namely job demands, user needs, and conceptual considerations.

a) Job demands

The obvious consideration in designing a computer information storage and retrieval system to fulfil job demands is in terms of 'task fit'; a system must be designed to cope with the characteristics of the information received, and the functions to be undertaken with it. This, in turn, implies that we should also assess the specific user group(s) concerned.

There are three characteristics of the information handled which need to be considered. First, different types of systems are needed to cater for different types of information. Some would need to store dynamic information: that in constant use and being continually updated. Others would store more static information, such as reference material, which requires updating fairly infrequently. Second, the form in which information is received and stored (e.g. on standard formats, as pages of text, etc.) necessitates due consideration of the structure and coding of information as outlined in Chapter 2 (sections 2.2.2.1 and 2.2.2.2). Third, a computer system must be able to cope with the volume and complexity of information received. There could be a large amount of complex information, or a small amount of non-complex information, or any other relevant combination.

b) User needs

Three types of office information storage were noted, namely 'action' information, 'personal work files', and 'archive storage'. Each are characterised by degree of relevance to on-going work activity: 'action' information constitutes on-going work, or that predicted for the near future; 'personal work files' consist of information stored in the user's office environment (e.g. in filing cabinets), which might be related to on-going activity or that which occurred in the recent past; 'archive storage' is usually a repository for information no longer directly relevant to the users work, but of possible use in the future. Consequently, the users degree of familiarity with the information corresponds to whether it is action information (very familiar) or archive storage (less familiar). There is less need for formal organisation of information with which we are more familiar; if we have handled something recently we have a shrewd idea of 'where' an item is, but we need a more formally organised retrieval strategy to access an item that has been archived. Therefore, it folllws that there is less need for retrieval aids with action information as opposed to archive storage.

However, the fact that larger systems of personal work files tended to be more organised suggests that there is a limit to the amount of information that can be accurately located based upon the memory of what was done with it. Organisation is required with large amounts of information in order that a pre-defined strategy can be followed if location memory fails in retrieval.

It might be beneficial to incorporate the three levels of information storage identified above into computer systems; the possibilities are discussed later in the context of conceptual considerations.

It was also apparent that users were not motivated towards elaborate filing procedures, mainly due to the time constraints of the job and because they found filing boring. With smaller systems this issue is not of major importance, and very large systems are often maintained by a secretary; unfortunately, manager and secretary do not always share the same conceptual model of the filing system. Difficulty arises mostly in systems which are not large enough to merit a secretary, but are large enough to require organisation. One can forsee an extra load, either in searching for lost items or in organising information, put upon users of these systems.

The introduction of computer information systems would therefore have to meet two requirements: firstly, that the system should impose on the user as little filing and organising of information as possible; secondly, that the strategy of computer storage should be compatible with the user's conception of it. Contemporary computer information systems can be based upon quite sophisticated databases requiring information definition in terms of complex descriptors; this requires the user to define each information item in complex terms. It is conceivable that the automatic filing of standardised documents could remove the need for complex procedures; however, this could result in the user's conceptual model not being appropriately updated. Some micro-systems can enter information into files but often there is not the capacity to structure them in a meaningful way to aid retrieval. Thus, the user has to spend time scanning long lists of file names. One answer might be to give users some support in terms of computer-based indexes or menu selection procedures; conceivably this would enhance 'ease of use'. However, it is probable that considerable research is still needed to develop such indexes or procedures.

Ideally, a computer system should be tailored to the information requirements of the specific user group; however, this is not usually viable in economic terms. On the other hand, flexible systems aimed at a range of user groups rarely provide an optimal solution and are sometimes inadequate in fulfilling the demands put upon them (Stewart, 1976). This dilemma is directly related to the software design, which necessitates 'ease of use' and 'user support' considerations Users should have an accurate concept of the relevant language, and of the operations and procedures necessary to execute desired functions. Also, when difficulties are encountered, appropriate support should be on hand.

It is probably better for naive users to be constrained by the system until some level of competence has been attained, when they are likely to require more flexibility; this will prevent the 'indirect consequence' of the job becoming boring and repetitive.

c) Conceptual considerations

If we are to design computer information systems which can be easily and successfully used by computer-naive people, then the required interaction should be in terms of concepts that these users understand. They should not have to learn a complex interaction language and they should find the necessary operations and procedures 'self-evident'.

Although some conception of the 'identity' of information items is of major importance, there is no doubt that a sense of 'whereness' is also a dominant organising principle used in most conventional information storage and retrieval systems. Information tends to be placed in 'functional' categories (e.g. administration), and also usually organised to two-levels in small and medium sized systems. It is easy to see that functional classification fits the user's conception of the tasks within his job, and that the reluctance to organise above two levels could be due to this approach. However, it may also be due to motivational factors, spatial awareness of information, or two levels being most compatible with users' internal categorisation processes. The contribution of individuals' well developed spatial awareness is illustrated by the fact that although they often had paper-based indexes, they used them infrequently. Generally, the required file could be directly located. Another point worth mention concerns the great variety of cues that people used in remembering an information item; for example, "the blue file", "the large folder", "the paper with the strange logo".

As yet it is difficult to relate directly to a computer in terms of 'putting your hand' on a document. Perhaps the future design of computer systems for naive users would benefit from the incorporation of spatial features, analogous to those present in the conventional filing system, to try to enhance the 'ease of use'.

An important conceptual consideration which relates directly to the three levels of information storage (action, personal work files, and archive), is the level of memory with which we need to interact. Our more frequent interaction with 'action' information makes it more likely that relevant details concerning retrieval will be stored in short-term or recent long-term memory storage. As we progress through to archive storage the likelihood is that we will require details from deep levels of long-term memory storage. We need to bear in mind that the type of concepts which are stored vary with the depth of memory; information recently stored will exhibit a wealth of detail, whereas the longer term storage becomes progressively more abstract and contextual (Herriot, 1974). Therefore, when using long-term memory storage we require a strategy for reconstructing the relevant details of information organisation, in the external environment, in order to promote item location. Moreover, it is apparent that strategic user support mechanisms, such as indexes, can be of more value the longer the period over which the information has been stored.

In discussing the implications for computer information system design, let us assume that we incorporate the three levels of information storage.

The development of a comparable 'action' information facility might well benefit from the incorporation of some analogue of the direct 'whereness' prevalent in the conventional filing systems. At present most computer information storage is more akin to archive storage, in that the information cannot be seen and the user has to have a model of the strategy of storage prevalent in the database. Some attempts have been made to remedy this by Bolt (1979) and Kay (1977).

Dr. Bolt has developed a spatial data management system, where users 'navigate' about a 'data plane' using joy-sticks and information is stored in specifically defined delimited areas. To access a piece of information subjects traverse to the relevant area and can then 'dive' through successive areas to the level of storage required. At all times they can see their position relative to the whole database on a small monitor by their side, whilst the encountered data are projected on a large screen in front of them. Dr. Kay's solution has been to develop a new interactive computer-language system called SMALL TALK. Information is presented in facsimile, animation, and graphic form, in an attempt to simulate our interaction with concepts in everyday life. Both Bolt and Kay have attempted to design systems with which naive users can interact in terms of interpretive skills that they have already attained, thus trying to increase the 'ease of use' of the system. However, both solutions are somewhat complex and need considerable 'backup'. Therefore, more practical versions are needed for incorporation into future information storage and retrieval systems.

Archive storage is much easier to accommodate on a computer; however, as already stated, interacting with it is not as easy. A computer personal work file level of information interaction might conceivably be based on some compromise between an 'action' and an archive level.

We have already discussed the important general consideration that people use a rich variety of cues to identify and locate information (e.g. colour, shape, when filed, etc.). Each extra source of information serves to enrich further our cognitive model concerning the identity and location of desired items, thus increasing the probability of retrieval. We have previously considered ways in which different types of formatting and coding can render an information display more legible (Chapter 2, section 2.2.2). In effect, we are enriching the available cues and points of reference from which our cognitive model of that display can be developed. However, too much cue enrichment can have a detrimental effect in that the display becomes confused. Therefore, these techniques should not be used indiscriminately, rather in a more judicious manner. Possible research in this area is discussed later in section 8.4.2.

Underlying the above results was the realisation that there were two main concepts relating to information items: First, a concept of identity, both descriptively and in relation to other items; second, a concept of how to retrieve the information, usually in terms of 'where' to look. These concepts, in turn, gave rise to the respective terms 'categorical memory' and 'spatial memory'.

Finally, we should bear in mind that the division between all three sections (job demands, user needs, and conceptual considerations) is not a rigid one, rather a subtle change of context. Job demands and user needs, for example, are intimately related, and conceptual considerations arise as a result of both.

8.3.3 Experiment 1 - The role of categorical and spatial memory in a simulation of the 'real world' filing of information

The purpose of this experiment was to investigate the nature of the relationship between categorical and spatial memory.

The major finding arising from the results, both of the experimental data and the subjects' comments, was that categorical and spatial memory appear to be separate and independent systems. They are possibly differentially interpreted by some kind of executive system; categorical processes being dominant in identifying information, spatial processes in locating it. This, in turn, suggests that identities are interpreted using categorical knowledge already stored in memory, whereas the spatial model is built up using externally perceived positional relations. The model of human information processing (Rasmussen, 1980) in Chapter 2 (section 2.3.1) also stresses the use of both internally stored information and information concerning the state of the external environment.

It may be noted that this appears to be a new experimental finding. It is, however, similar to the dual-coding hypothesis (Pavio, 1971) which proposes separate verbal and imaginal processes in memory.

Both categorical and spatial memory can provide cues for the retrieval of information; therefore it would seem logical that both types of cues could be used to locate descriptors on computer displays. It might be advantageous to employ information descriptors compatible with the user's internal functional categorisation of his task and then display them in an optimum format. The experiment would lead us to believe that the spatial organisation of descriptors was unimportant and that they could be equally well located irrespective of layout. However, we intuitively know that it is difficult to locate file names in random lists of files displayed by a computer. A probable reason for this is the appreciable difference between a two-dimensional array of pigeon holes and a one-dimensional, flat, random list of file names. One answer might be to arrange lists of file names into two dimensions to improve location ability (see later discussion, section 8.3.5).

Here we must take into account the specific nature of the spatial model produced as a result of filing in the pigeon holes. It was apparent that the outer ones were more easily located, and that they formed points of reference for the model. It would seem sensible, therefore, to arrange for the most important information (e.g. operating mode) to be displayed at the extremes of the display. However, we should never consider an experimental result such as this in isolation from other formatting considerations (Chapter 2, section 2.2.2.1); we might, for instance, disrupt the logical sequencing and grouping of the information. The spatial characteristics of a display are evidently quite important, as many of the subjects commented that they naturally try to recall an image of the information, even if it was not used as the basis of a recall strategy.

8.3.4 <u>Experiments 2-5 - The effect of lists of progressive spatial and categorical structure on the free and spatial recall of job categories</u>

Experiments 2 to 5 were a natural progression from experiment 1 in that they attempted to simulate computer as opposed to conventional filing; that is, the use of one-dimensional lists of categories.

In keeping with the results obtained in experiment 1, experiments 2 to 5 again provided a wealth of evidence of the independence of categorical and spatial memory. However, there was evidence of a very general level of spatial organisation in free recall, even though the recall strategy was predominantly categorical; it is possible that subjects used the general spatial framework of the list to orient recall of job categories. Results also demonstrated that internal categorical organisation was directly related to explicitly perceived, meaningful categorical relations. Furthermore, the stronger and more meaningful job category associations were much more likely to be incorporated into the categorical memory model of the information. The amount of internal categorical organisation was also positively correlated with the number of job categories successfully recalled. Implicit presence of categorical structure in randomly arranged job categories did not promote concommitant memory organisation to such a degree.

It is conceivable, therefore, that we could augment a user's categorical model of computer information by explicitly displaying meaningful relations. The crux of this statement is 'meaningful'; it does not advocate 'meaningful' to the systems designer, but 'meaningful' to the people who have to use the system. Consequently, we could promote an efficient strategy for the recall of information, and therefore promote a maximum amount of understanding of the relevant inter-relationships. One way of achieving this is to group categorically related items together spatially (Stewart, 1976).

However, a prerequisite is that we must first discover what is meaningful to system users in relation to the appropriate task content, before we can design accordingly; for example, often people perceive the relationship between information items in different ways. It is with this type of problem that psychological research can make a positive contribution.

The spatial model of the lists also seemed to be dependent upon perceived categorical relationships as well as spatial; spatial arrangement according to the categorical relationships resulting in greater location accuracy. This implies that the retrieval of spatial information from memory involved an additional categorical interpretation strategy. This, in turn, implies that whereas categorical grouping was not of paramount importance for an efficient spatial 'image' when using an array of labelled pigeon holes, it was when using lists of descriptors. In fact, when experiment 1, condition 3 (using randomly arranged labelled pigeon holes) was compared with experiment 2 (using randomly arranged lists of category labels), the subsequent spatial location ability of subjects in the former situation was significantly superior to those in the latter situation. Spatial grouping of the lists (experiment 3) brought about some improvement, but only categorical grouping (experiments 4 and 5) put performance on a par with that observed as a result of pigeon hole filing. However, there was one aspect of subjects' spatial models evident throughout the list experiments: spatial recall of the top and bottom of the lists was consistently superior to that of the section between.

It was obvious that there were important cues present in the pigeon holes that were missing in the lists (see later details in section 8.3.5), which had to be compensated for by imposing a categorical strategy of interpretation.

A plausible explanation for this lies in the presence of an executive interpreting mechanism. It is conceivable that, in the absence of strong spatial cues providing a strong spatial 'image', some other strategy, in this case categorical, can be used to provide location information. The implication of this is that the executive system needs to process systematically some form of organised information, whether it be via points of spatial reference or in terms of meaningful categorical relationships. When both categorical and spatial relationships are present the executive system might use either type of strategy. If particularly strong points of spatial reference were available then a strategy based on them might predominate in spatial recall; if not, a strong categorical strategy, if available, might prevail.

This would certainly explain why the pigeon hole array with its many points of spatial reference elicited a comparably high spatial location ability irrespective of the arrangement of job categories. Conversely, the lists with their fewer points of spatial reference exhibited the need for a categorical strategy of interpretation; thus increasing the importance of a meaningful arrangement of job categories. The strategy used, in light of the results obtained, seems to involve first locating descriptors in terms of their major category group (e.g. Academic) in relation to the whole list; then the order of the job categories within the group is sorted out, possibly using the top and bottom of each group as points of reference and ordering the job categories according to recalled inter-item associations. Thus, it seems reasonable to suggest that a categorical strategy, if available, can compensate for the absence of a strong spatial memory model.

One might justifiably ask why a person might want to locate a descriptor from a computer display. Would it not be more efficient to recall descriptors directly from memory, and type them into the computer as part of a statement to access an associated item of information?

However, the free and spatial recall of job categories in experiments 2-5 exhibited approximately a 14% incidence of misnaming. Although it was clear to another human what each mistake was referring to, the literal translation of most computers will not tolerate this kind of error. Therefore, to counteract this human tendency it makes good sense to provide a display of descriptors from which people can choose. In this context Bennett (1979) confirmed the well known psychological maxim, that recognition is easier than recall (Kintsch, 1970). Otherwise, much programming effort must be spent to ensure that synonyms of commands and descriptors are acceptable to the computer.

It is plain to see from previous discussion, however, that we cannot assume that people will be able to locate descriptors as easily from lists displayed by a computer, irrespective of their arrangement, as they could with pigeon holes. Emphasis must be placed upon the explicit organisation of information. If this requirement is met then users will find it easier to locate a relevant piece of information on a screen. For example, if we need to know the name of a particular file it would be much easier to locate that descriptor in a structured list of file names than in an unstructured list; this is supported by the significantly faster times for item searches, during the training periods, when using the categorically structured lists. Often, when memory fails us, it is comforting to have this kind of support.

8.3.5 Experiments 6-8 - An investigation of the factor(s) contributing to a 'strong' spatial 'image'

Small subsidiary experiments were carried out with the intention of determining the factors contributing to the superior spatial 'image' of the randomly arranged pigeon holes (experiment 1) in comparison to the random list arrangement (experiment 2). The results showed that the major contributory factor was the two-dimensionality of the display: grouping the random lists into two dimensions improved the spatial 'image' to a level on a par with that of the randomly arranged pigeon holes.

Hence, we have another useful guideline for the structure of information on computer displays. Randomly arranged descriptors are best grouped into two dimensions (i.e. across the display) if users are to form a spatial model which confers a high level of descriptor location. Additionally, these experiments showed that there was no detriment to the spatial model when a much smaller graphic analogue of the pigeon holes was used as a display.

8.3.6 Experiment 9 - Comparison of memory models arising from the use of 2- and 4- level indexes

The initial survey of office information organisation (Chapter 3) revealed that people generally categorised information to two levels, and also that they often had indexes but did not use them frequently. Therefore, the logical progression was to investigate whether two or a greater number of levels of categorisation was the optimum conceptual arrangement. In order to do this, subjects used paper-based 2- and 4-level indexes, the intention being to test the resulting conceptual models formed. In addition, it enabled us to assess the types of index support which could be most profitably displayed to the user by the computer.

The results showed that a 2-level index was easier to use than a 4-level index. Also, it was evident that the categorical memory model arising from the use of the 4-level index was no more extensive than that arising from the 2-level index; only the highest and lowest levels were incorporated. However, there was evidence that the 4-level index conferred a superior spatial model, as indicated by recognition decision times of words originally on the index. It will be remembered that at level 4 of the 4-level index used in this experiment (see Figures 7.11 to 7.13) the stimulus words were separated into small sub-groups, with distinct 'paths' to them through the four levels; this was not the case for the 2-level index where the stimulus words were simply grouped into blocks. Hence, the 4-level index provided more characteristic spatial features which could be incorporated into the spatial memory model.

When given no instructions to do otherwise, people seem to prefer to conceptualise information organisation in only two levels. It is likely, therefore, that this is a contributory factor to peoples' natural tendency to organise their office information to two levels. Furthermore, there would seem little point in organising computer-based indexes past two levels. However, this only applies to indexes where all levels of classification are simultaneously on display, and also where only approximately 60 descriptors are listed; a more extensive index might well require further classification. Also, even though the 4-level might confer a superior spatial model of the information, having to attend to each level in turn, to discover, for example, a classification number, tends to take longer than searching two levels.

8.3.7 Summary and guidelines

It is possible to summarise the previous work and provide useful guidance with respect to systems design for non-computer professional users. The emphasis is placed upon the design of computer information storage and retrieval systems and for it to be human-centred rather than system-centred. The important points are as follows:

A. Task fit

A.1 Task analysis is essential, so that the designer understands the implications of his design in relation to the users' jobs.

A.2 The designer must assess the characteristics of the user group(s) involved, namely their background and level of sophistication concerning computer use, consequently there is a need to:

a) decide the level of constraint put on the user by the system,

b) reach a compromise between the flexibility and specificity of the system,

c) decide upon the level of user support.

A.3 We should be aware of the users' functional conceptions of the tasks which compose their jobs (conceptual considerations).

A.4 Job demands should be noted as follows:

a) Type of information - how is it going to be used (dynamically or as reference).

b) Form of information - the information medium format, nomenclature etc.

c) Volume and complexity of information.

A.5 Action information vs. personal work files vs. archive storage.

The considerations associated with the various levels of information storage are, as yet, unproven as regards their validity for man-computer interaction. They are illustrated in figure 8.1 following:

Action information ⟶ Personal work files ⟶	Archive storage
i) Detailed knowledge of information and its whereabouts.	i) Contextual knowledge of information, less sure of its whereabouts.
ii) Of direct relevance to present work.	ii) Possibly indirectly relevant to present work.
iii) Short term memory and recent long term memory considerations.	iii) Long term memory considerations.
iv) Predominant spatial awareness of information.	iv) Predominant awareness is of information categories.
v) Limit to the amount of information that can be related to in direct spatial terms.	v) A very large amount of information can be related to with the correct strategy.
vi) Requires minimum organisation.	vi) Requires extensive organisation.
vii) Requires little retrieval aid (i.e. indexes or other user support).	vii) Retrieval most efficient using retrieval aids.

N.B. Personal work files should be considered a hybrid of the two extreme levels.

Figure 8.1 - Summary of information levels and related considerations.

A.6 Users' prefer to have to spend as little time as possible actually filing.

B. Ease of Use

B.1 We should be aware of how users conceptualise information, in order to gain an understanding of their 'world model'. Possible types of concepts as derived from the literature survey are:

a) Semantic - verbal and categorical concepts.

b) Imagery - 'images' play a role in the mediation of verbal concepts, conveying pictorial concepts (e.g. graphs) and in a global appreciation of information relationships.

c) Episodic - autobiographical information of events and their temporal sequence (e.g. when something was received).

d) Task specific - users conception of his job, and the projection of its structure on to the organisation of the computer system.

e) Abstract functional - available computer functions and their specific combination into higher level functions; also, the abstract language expression of functions (semantics and syntax).

From the research reported in this thesis, to the above should be added spatial concepts; these could be construed as a form of imagery, but they are important enough to merit special attention.

N.B. Spatial awareness is a naturally dominant concept in humans, therefore some kind of spatial analogue might be useful in computers.

B.2 Information should be organised in a manner compatible with the systematised human information acquisition and interpretive processes:

a) Strategies and plans should attempt to match or facilitate those already available to the users;
b) system rules should be logical in terms of human information processing rules (e.g. language);
c) computer-aided problem solving should progress in an easily understood manner, according to human problem solving characteristics;
d) users should be aware of the machine's limitations;
e) information should preferably be organised to two-levels of classification if the system is not too large.

B.3 Users have an identity (categorical) memory and a spatial memory which are separate and independent.
Users:
a) develop a categorical memory model based upon internal knowledge of information relations,
b) develop a spatial memory model based upon externally perceived information relations.

N.B. With the strong spatial 'image' arising from a 'real world' information system (e.g. pigeon-holes) the external organisation of information is not an important consideration. However, it is an important consideration when considering the display of information on a 'flat' VDU.

B.4 Three ways of formatting file descriptors to improve their spatial locatability are:
a) Grouping in one dimension according to 'meaningful' superordinate categories.
b) Grouping in two dimensions. (Presumably one might expect additional categorical organisation to confer an extra advantage.)
c) Displaying descriptors in a schematic analogue of a pigeon hole array.

B.5 An enhanced spatial memory model, resulting from optimum structuring of the information display, promotes faster location of descriptors.

B.6 There are a number of other formatting and coding considerations which can be used to improve the 'meaningfulness' of displayed information (Stewart, 1976, see chapter 2).

N.B. Formatting and coding should not be used indiscriminately because there is a possibility of two or more types working against one another, thus causing confusion.

C. User support (for indexes whose total classification scheme is on display simultaneously).

C.1 A two level index is easier to use than a four level index.

C.2 The extra levels of classification, above two, confer no advantage to the efficacy of the categorical model of the information.

8.4 Further research

8.4.1 Verification of guidelines

The considerations and guidelines listed in section 8.3.7 are in some instances somewhat tentative. For instance, spatial awareness was found to be a predominant concept in the use of conventional filing systems. However, the value of spatial awareness for the use of information displayed on a computer terminal is based on the valid assumption that recognition is easier than recall. Therefore, we need to assess the value of increased spatial awareness of displayed information. The verification would require us to monitor the interaction of users with displays which conferred both high and low spatial awareness. Their subsequent performance and reactions would test the value of strong spatial cues in the computer context. This study could be successfully incorporated into the assessment of cue enrichment described in the following sections.

Similarly we need to examine the efficacy of providing different levels of information (action information, personal work files, and archive storage), and whether the associated characteristics (figure 8.1) observed in the conventional office environment, can be advantageously introduced into computer

In addition to the verification of guidelines, there are two specific and related areas of research which could be profitably examined. But first, let us consider an overview of present work and relate it to that which needs to be done in the future.

8.4.2 A schematic overview of present and proposed research

Figure 8.2 shows a schematic overview of the relationship between the present research and that which could be usefully undertaken in the future.

It can be seen that the office survey (figure 8.2, B; see chapter 3) arose from the literature survey to fulfil the need to set an appropriate context for subsequent research; the findings can be seen listed in B. As the result of a particular survey finding, that information usually had identities and spatial locations associated with it, experiment 1 was formulated; this was to examine the relationship between categorical and spatial memory using a simulation of a conventional filing task (figure 8.2, C; see chapter 4).

The research then progressed to similar investigations, using simulated computer filing tasks, in experiments 2 to 5 (figure 8.2, D; see chapter 5).

A comparison of the results of experiment 1 with those of experiments 2 to 5 highlighted a major difference in the spatial memory models of the two tasks. Therefore, experiments 6 to 8 were formulated in order to ascertain the factor(s) responsible for the difference (figure 8.2, E; see chapter 6).

At this point it was felt that this particular line of experimentation had progressed sufficiently far, and that a new line ought to be followed. Consequently, another survey finding, that people usually organise their filing systems to only two levels of classification, was chosen as the basis for a further experiment. As a result experiment 9 was designed: this was an investigation into the use of two and four-level indexes and the cognitive models resulting from their use (figure 8.2, F; see chapter 7).

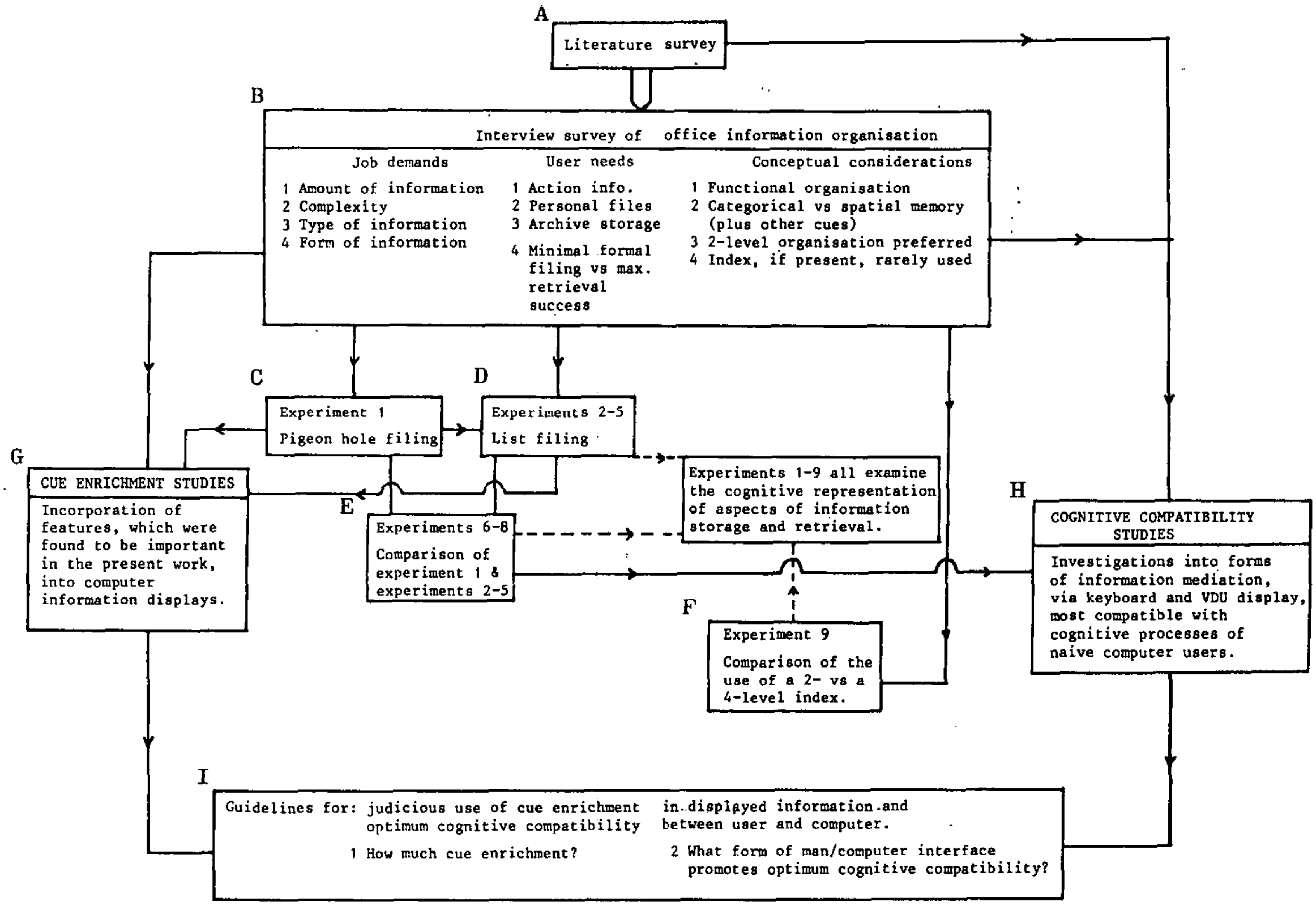


Figure 8.2 - Schematic overview of the relationship between the present and proposed future research

Due to time constraints the experimentation could progress no further. However, it was felt that there were two areas in particular which merited further research: cue enrichment studies and cognitive compatibility studies.

The impetus towards cue enrichment studies (figure 8.2, G) arose from all the work that had been undertaken (cue enrichment is discussed in more detail in section 8.4.3). It was evident that not only did subjects incorporate cues provided by the experimenter into their memory models, but they also used various non-experimenter defined cues to characterise information: for example, they used colour, physical features, episodic information, etc. Therefore, it is probable that one of the reasons why people find it hard to relate to computer-based information is that very few cues are available in the information displayed; in comparison, the 'real world' has a multitude of different cues available, contributing to an informationally rich environment. It follows that experiments should be undertaken in order to examine the feasibility of enriching the available cues in computers.

In general terms cognitive compatibility is the provision of a suitable, computer system whose means of operation are readily apparent to users in terms of concepts which they already have available; more detail will be given in section 8.4.4. This will enable the user to form an appropriate cognitive model of his interaction with the system.

The need for cognitive compatibility studies (figure 8.2, H) was identified mainly due to the consideration of the literature survey, and office survey findings, in the light of known computer system characteristics. Also, the importance of certain system design features, to promote the formation of an effective cognitive model, was readily apparent from experiments 1 to 9; in this case aspects of the information display structure.

Finally, it was felt that the end result of the present and proposed work should be a set of comprehensive design guidelines (figure 8.2, I). This would enable systems designers to take more account of the cognitive characteristics of users in the future design of computer systems.

In the following two sections the specific studies, which propose to investigate cue enrichment and cognitive compatibility, are discussed.

8.4.3 Cue enrichment studies

It is apparent from the work described in this thesis that there was potentially a wealth of different cues associated with stored information which could contribute to its subsequent retrieval. These cues contributed specifically to the identification and location of information relevant to task-defined requirements. In comparison, the retrieval of information from a computer is biased toward the definition of required information either in terms of index codes, numerical or alpha-numeric, or in terms of some natural language, or abbreviated natural language, descriptor. The 'location' of information is undertaken by the computer, and so no extensive spatial cognitive model is available to the operator. At best, the only spatially oriented model is in terms of successive VDU file listings. Often file listings have to be scanned to find the appropriate code or descriptor needed to access a particular piece of information.

Can we learn some lessons from the way people conceptualise information in the office, and in pigeon hole and list experiments, in order to facilitate information access from computers? A number of experiments can be formulated in order to investigate the possibilities of cue enrichment. These experiments would all incorporate the same computer system and task. Time and error scores could be recorded, along with subjective reports of their adopted strategies and the difficulties that they encountered. The independent variable would be the introduction of some feature of the display thought to be important in relation to the previous work;

the effect of its presence could be assessed by comparison with a control group's performance. Possible independent variables are as follows:

a) different formats for the screened information, based upon the previous research findings;
b) the use of elaborate computer simulated 'real world' features such as 'pigeon-holes', 'drawers', and 'window access';
c) colour coding functionally related information, or sections of the display.

Much work has been done in these areas in the past, and recommendations have subsequently been made regarding types of formatting and coding information which can be advantageous (Stewart, 1976). However, there are few guidelines concerning how much and in what combinations these features should be used. Indiscriminate, or too much use of information structure and coding can be as detrimental to performance as not using them at all. Therefore, the importance of relevant guidelines can be appreciated.

It is possible that some of the features, such as analogues of conventional filing equipment, might not improve performance with the system. However, they may be instrumental in rendering the system more 'acceptable' to the user, and more 'comfortable' to use. This would conceivably help to break down the barrier of apprehension that many non-computer professionals feel when using a computer.

8.4.4 Cognitive compatibility: control/display relationships of computer information systems

In the office filing system, the mediation between the users and their information consists of the physical location of information via some internal cognitive map. The mediation in a computer information system is usually via a QWERTY keyboard and the entry of some descriptor in conjunction with some pre-defined operational sequence. The keyboard mediation is less direct and more abstract, and the information required is either 'invisible' or displayed, in part, on a VDU screen. There is not direct access of information in the sense of office filing system retrieval, rather a more abstract specification of needs. Therefore, the relationship between the database and mediating operational sequence is not as straightforward as in the conventional office environment. How do we, for example, develop a global conceptual model of our interaction with information represented by the successive display of menu choices indicating the possible categories? We need to discover which systems alternatives are compatible with users' cognitive models or level of understanding. We should aim for cognitive compatibility between the user and system.

Cognitive compatibility is the match between the functions and operations of the computer and how the user perceives and conceives them. When cognitive compatibility is not present then a cognitive mismatch results and the system becomes unacceptable to the user. There are three questions that are particularly relevant in assessing the relative conceptual compatibility of computer systems:

a) Which system is most efficient in terms of time and errors resulting from a standard task?
b) Which system promotes the most efficient cognitive model, for non-computer professionals, in terms of decision time on a standard task?
c) Which system is subjectively more acceptable?

In turn, there are a number of research issues that these questions should be applied to:

a) Should the computer information filing and retrieval functions be QWERTY keyboard mediated commands or high-level function keys in a layout compatible with information display or data base organisation?
b) Is it better to provide the flexibility for people to develop their own filing systems using a computer, or for them to be constrained within a computer-defined system?
c) Why do people get lost in a menu selection system which is organised to more than four levels? There are three possible areas of experimentation that would be interesting:

i) The provision of a schematic reference diagram, representing the relationship of all the major information areas, as a useful aid to 'navigation' in a complex menu selection system.

ii) Would menu choices made by pressing keys arranged to be spatially compatible with the displayed alternatives provide a more efficient and acceptable system?

iii) A general assessment of touch sensitive screens, cursor manipulation, and light pen for menu selection.

Obviously, cue enrichment and cognitive compatibility studies are just two of the many possible areas in which valid research could be undertaken. Users' conceptualisations of their interaction with computers can be investigated in many contexts, both task dependent and independent. It is very important for them to develop an appropriate cognitive model, not necessarily in terms of computer professional concepts, but in terms that they can readily understand.

The need for further research into cognitive issues in the context of man-computer interaction is proposed by Shackel (Infotech State of the Art Report: Man/Computer Interaction, 1979):

".. some examples, but relatively few, have been given of some of the issues and approaches being studied in this new area of cognitive ergonomics. Many other aspects are being worked on, partly because of the stimulus afforded by rapidly growing computer technology. In general there is still very much more intuitive opinion, pragmatic experience and expert advice, as a basis for cognitive ergonomic recommendations to assist MCC design, than there is hard experimental evidence. Indeed the success, and also the problems, of existing systems depend very largely on the pragmatism and intuition of computer designers and very little upon ergonomic knowledge. However, some of the gaps and problems with existing systems reveal the need for considerable growth in cognitive ergonomics".

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32 References

APPENDIX 3.1

Ian Cole - Research Student

Department of Human Sciences (HUSAT)

Structured Interview for initial information gathering in the study of Personal Filing Systems.

Stage 1 - Basic Considerations and General Structure

1) Job description -

2) Why is it necessary to keep information?

3) Basic considerations:-

   i) Is certain 'action' information kept outside the filing system for matters being dealt with or to be dealt with? Where is it kept?

ii) If 'action' information is kept, is it material just received or is it mixed with relevant documents retrieved from the system?

iii) What are the important factors dictating the amount of time spent filing?

iv) Does a secretary help with the filing?

v) Do other people need to use any, or part, of the information and is the filing system, or relevant part, designed with this in mind?

vi) Is the filing system designed with a specific retrieval plan, or retrieval plans, in mind?

4) Structural considerations:-

i) What general types of information are stored, e.g. administrative (personnel etc.), teaching, project progress (technical/research)?

ii) Are some general information types used more than others? Why? Is more structure evident? (tie up with type of job)

iii) Within these broad categories are files created based on:-

a) Origin of information?
b) The common function that the information might be called upon to facilitate although it might be from different origins?
c) The origin of the information and the function the information facilitates?

iv) Are these broad categories of files laid out in any logical order?

v) Are the files appropriately titled?

vi) Are the files stored in:-

a) Alphabetical order?
b) Chronological order depending on when created?
c) No particular order, reliance being upon memory of their location?
d) No particular order, reliance being on scanning files to find the relevant one?
e) Colour coding?
f) Any combination of the previous? Explain.
g) None of these? Explain.

vii) Is there overlapping between categories?

viii) What types of documents are stored in the files?

a) Memos
b) Letters
c) Assorted personnel records
d) Progress reports
e) Paperwork concerning employment of staff
f) Various financial statements and evaluations
g) Notes and minutes of meetings
h) General information concerning established systems
i) Factual information (technical/research)
j) Other types

ix) Are these documents stored in:-

a) Alphabetical order?
b) Chronological order?
c) No particular order, reliance being on the memory of location?
d) No particular order, reliance being on scanning to find?
e) Any oombination of these? Explain
f) None of these? Explain

x) Was the system:-

a) Consciously organised bearing in mind what he asked of it?
b) Evolved by allowing the nature of information received, or generated, dictate the organisation?
c) Evolved by putting files in the first handy place available?
d) Any oombination of these?

xi) Are there problems in categorising certain documents?

If a difficulty arose would a) New files be created rather than filing inadequately in existing categories?
b) Documents put in a vaguely related file and their location remembered?

xii) Is there any cross-referencing within the system? (Extent)

xiii) Is the system hierarchically organised to any extent?

xiv) Could benefit be gained from a more structured filing system. What are the reasons for lack of structure.

Ian Cole - Research Student
Department of Human Sciences (HUSAT)

Structured interview for initial information gathering in the study of Personal Filing Systems.

Stage 2 - Storage and Retrieval

Discuss comments on back.

N.B. Different parts of the system which are more, or less, familiar, may require different strategies.
Key considerations:-

i) To what extent did the memory of a particular file and/or document location play a part in the storage/retrieval of items of information?

ii) For files:-

Did they remember:-

a) Location of certain files?
b) Title of a file, then rely on scanning the cabinet to find it?
c) Physical characteristics of a file, then rely on scanning the cabinet to find it?

For documents:-

Did they remember:-

a) Appropriate location in the file?
b) Deduce the approximate location from knowledge of the document and the strategy of document storage?
c) Remember the physical features and scan for it?

iii) Is information thrown away? What criteria are employed in either keeping or throwing away information?

iv) What common difficulties are encountered with storage and retrieval, and what common errors are made?

APPENDIX 4.1

General

There were five major categories of student employment opportunities each of which were broken down into six job categories. The five major categories were:

Public services

Industry

Commerce

Academic

Miscellaneous

Examples of information from each of the job categories of each major category follow:

PROBATION AND AFTER CARE SERVICE IN ENGLAND AND WALES

Several opportunities for graduates to work in all areas of probation work.

Send for details to:

Probation and Ater-care Department,
Home Office,
Romney House,
Marshall Street,
LONDON SW1 3DY.

CIVIL SERVICE

HER MAJESTIES INSPECTOR OF TAXES

Approximately 100 vacancies for trainee inspectors in 1979.

Send for details to:

Appointments in Administration Scheme,
Income Tax Recruitment,
Allendon House,
LONDON WC1A 2BJ.

LOCAL AUTHORITY

LEICESTERSHIRE COUNTY COUNCIL

Social science graduates needed to work in the personnel department.

Send for details to:

Mr. Almond,
County Hall,
Glenfield,
LEICESTER LE11 3TE.

NATIONAL BUS COMPANY

Opportunities are available for graduates who wish to work in public transportation.

Send for details to:

Personnel Manager,
National Bus Company,
18/19 Jipping Street,
LONDON WC1 8QJ.

MEDICAL

DERBY ROYAL INFIRMARY

Graduates are invited to apply for posts as nurses working towards both SEN and SRN qualifications.

Send for details to:

Registrar,
Derby Royal Infirmary,
Derby.

ARMED FORCES

ARMY

Officer commissions are available, in the combat and support arms of the army, for graduates.

Send for details to:

Graduate Recruitment Officer,
Graduate Induction Centre,
Aldershot.

PERKINS ENGINES COMPANY

Opportunities are available for engineering graduates to start a career in engineering with us.

Send for details to:

Graduate Recruitment Manager,
Perkins Engines Limited,
Eastfield,
Peterborough PE1 5NA.

INDUSTRIAL ADMINISTRATION

MANAGEMENT TRAINING

SONY U.K. LIMITED

Sony offers management training opportunities to graduates who want a career in management.

Send for details to:

Andrew Goodwin,
Personnel Officer,
Kingsway Industrial Estate,
Bridgend,
Mid Glamorgan CF31 3UP.

BRITISH STEEL CORPORATION

Graduates are required to work in our industrial purchasing departments at Port Talbot and Llanwern.

Send for details to:

Co-ordinator,
Graduate Recruitment,
Head Office,
British Steel Corporation,
33 Grosvenor Place,
LONDON SW1X 7JG.

QUALITY CONTROL

ACCOUNTANCY

BARRON, ROWLES AND BASS

10 vacancies for graduates to become trainee accountants, to work towards becoming a fully qualified chartered accountant.

Send for details to:

R.J. Stevens,
Barron, Rowles and Bass,
12 John Street,
London WC1N 2EB.

STOCKBROKING AND INVESTMENT ANALYSIS

INSURANCE

ENDSLEIGH INSURANCES (BROKERS) LIMITED

We market a complete range of insurances through a nationwide network of advisers. There are vacancies for graduates to become insurance advisers under an area manager.

Send for details to:

The Personnel and Training Manager,
Endsleigh Insurances (Brokers) Ltd.,
Ambrose Street,
Cheltenham Spa,
Glos. GL50 3NR.

BANKING

MIDLAND BANK LIMITED

Careers are available in most aspects of banking for university graduates.

Send for details to:

The Manager,
Graduate Recruitment,
Midland Bank Limited,
Countwood House,
Silver Street,
SHEFFIELD S1 3RD.

RETAILING

F.W. WOOLWORTH AND COMPANY LIMITED

We run a retail store chain throughout the U.K. and need graduates to fulfil positions in all aspects of retailing.

Send for details to:

D.A. Murphy Esq.,
F.W. Woolworth and Co. Ltd.,
Woolworth House,
242/246 Marylebone Road,
LONDON NW1 6JL.

ADVERTISING

MSC COURSES - SOCIAL SCIENCES

TEACHER TRAINING

MA COURSES - ARTS

UNIVERSITY OF ESSEX.

Applications are invited for places on the Aesthetics and Theory of art course, leading to an MA qualification.

Send for details to:

Registrar,
University of Essex,
Wivenhoe Park,
COLCHESTER CO4 3SQ.

PHD RESEARCH

<ins>THE UNIVERSITY OF KENT AT CANTERBURY</ins>

Applications invited for PhD research into EEG correlates of behaviour. A 2/1 or 1 honours degree in an appropriate subject necessary.

Send for details to:

Academic Registry,
University of Canterbury,
KENT CT2 7SZ.

PART-TIME EDUCATION

UNIVERSITY OF NORTH WALES AT BANGOR

Part-time courses are available in the department of civil engineering for suitably qualified graduates.

Apply to:

Prof. E. Jones,
Department of Civil Engineering,
University of North Wales at Bangor,
Bangor,
Gwynedd LL57 2DG.

ENVIRONMENTAL CONTROL AND DESIGN

THE IDC GROUP LIMITED

Graduates of architecture and related subjects needed to work in design of environments in relation to building construction.

Send for details to:

Training and Personnel Executive,
IDC Limited,
Timothy's Bridge Road,
Stratford-upon-Avon,
Warwickshire CV37 9NJ.

TOURISM

AVIS CAR RENTALS LIMITED

Graduates needed to work in our overseas offices catering for tourist transport needs.

Send for details to:

Peter Jones,
U.K. Personnel Manager,
Trident House,
Station Road,
Hayes,
Middlesex UB3 4DJ.

HOTEL MANAGEMENT AND CATERING

MORGAN-GRAMPIAN LIMITED

3 vacancies available for graduates to become technical journalists.

Send for details to:

P.G. Clements Esq.,
Assistant Secretary,
Morgan-Grampian Limited,
30 Calderwood Street,
Woolwich,
LONDON SE18 6QH.

SOLICITORS IN ENGLAND AND WALES

Law graduates are welcome to enquire after possible careers available in the legal profession.

Send for details to:

The Secretary,
Education and Training,
The Law Society,
113 Chancery Lane,
LONDON WC2A 1PL.

THE RANK ORGANISATION

Applications are invited from graduates to work in various aspects of entertainment and leisure provided by the Rank Organisation.

Send for details to:

Staff Development Officer,
The Rank Organisation,
11 Hill Street,
LONDON W1X 8AE.

APPENDIX 4.2

SUBJECT

NAME

CONDITION

EXPERIMENTAL ORDER

EXPERIMENTAL TIME

GROUP

TRAINING ORDERS

TRAINING TIMES

DATE

COMMENTS:

DATE

QUESTIONS FOR SUBJECT.

1) Were you aware of any major categories of information?

2) What strategy did you adopt for the reading of each item of information?

3) What strategy did you employ for the first part of recall?
(Show their free recall list)

---

4) What were the reasons for recalling the items after you had drawn a line?

5) What strategy did you employ for the second part of recall?
(Show their spatial recall diagram)

APPENDIX 4.3

Program for the generation of nine randomised lists of the numbers 1 - 30.

```
90   RANDOMIZE
100  DIM L(30)
110  FOR T = 1 TO 9
150  FOR I = 1 TO 30
160  LET L(I) = I
170  NEXT I
200  FOR N = 1 TO 30
220  I = INT(30*RND) + 1
280  LET X = L(I)
300  IF X<O THEN 220
310  PRINT X
320  L(I) = -1
340  NEXT N
342  PRINT "______________________________________________"
345  NEXT T
360  END
```

LIST 1.

Civil service

Stockbroking and investment analysis

Environmental control and design

Medical

Quality control

Part-time education

Management training

MSc courses - Physical sciences

Hotel management and catering

Accountancy

Journalism

Teacher training

Industrial administration

Tourism

Local authority

PhD research

Advertising

Management services

Engineering

Legal work

Armed forces

Banking

Entertainment

Social work

Buying

Public transport

MSc courses - Social sciences

Retailing

MA courses - Arts

Insurance

LIST 2.

Management services
Buying
Civil service
Management training
Stockbroking and investment analysis
Part-time education
MSc courses - Physical sciences
Retailing
Quality control
Legal work
Advertising
Teacher training
MSc courses - Social sciences
Social work
Medical
Industrial administration
Accountancy
Journalism
Hotel management and catering
Engineering
MA courses - Arts
Tourism
Armed forces

Public transport
Insurance
Entertainment
Banking
PhD research
Local authority
Environmental control and design

LIST 3.

Buying
Tourism
Stockbroking and investment anlysis
Public transport
Journalism
MSc courses - Physical sciences
Insurance
Banking
Engineering
Legal work
Medical
Part-time education
Local authority
Entertainment
Management training
Industrial administration
Quality control
Management services
Hotel management and catering
Accountancy
MSc courses - Social sciences
Teacher training
MA courses - Arts
Social work
PhD research
Advertising
Environmental control and design
Armed forces
Civil service
Retailing

LIST 4.

Insurance

Journalism

MSc courses - Social sciences

Banking

Engineering

Management training

Public transport

Advertising

Environmental control and design

Accountancy

Medical

Local authority

Management services

Retailing

MSc courses - Physical sciences

Civil service

Industrial administration

Teacher training

Tourism

MA courses - Arts

Social work

Stockbroking and investment analysis

Legal work

Buying

Hotel management and catering

Entertainment

PhD research

Part-time education

Armed forces

Quality control

LIST 5.

Medical

Banking

Retailing

Armed forces

Tourism

Public transport

Legal work

Accountancy

Buying

Mangement training

Journalism

Teacher training

Engineering

Part-time education

Advertising

Insurance

PhD research

Mangement services

MA courses - Arts

Stockbroking and investment analysis

Local authority

Hotel management and catering

Environmental cantrol and design

Civil service

Social work

Industrail administration

MSc courses - Physical sciences

MSc coorses - Social sciences

Entertainment

Quality control

LIST 6.

Buying

Civil service

Legal work

MA courses - Arts

PhD research

Entertainment

MSc courses - Social sciences

Hotel management and catering

Accountancy

Management training

Medical

Social work

Local authority

Stockbroking and investment analysis

Tourism

Part-time education

Teacher training

Quality control

Management services

Envirinmental control and design

Advertising

Insurance

MSc courses - Physical sciences

Public transport

Engineering

Journalism

Banking

Armed forces

Industrial administration

Retailing

LIST 7.

Tourism

Entertainment

Medical

Legal work

Quality control

PhD research

Journalism

Armed forces

Hotel management and catering

Teacher training

Civil service

Engineering

Insurance

MSc courses - Social sciences

Local authority

MA courses - Arts

Banking

Buying

Part-time education

Accountancy

Retailing

Industrial administration

Advertising

Social work

Public transport

Management services

Management training

Stockbroking and investment analysis

MSc courses - Physical sciences

Enviromental control and design

LIST 8.

Part-time education
Accountancy
Quality control
Local authority
PhD research
Retailing
Public transport
Engineering
MSc courses - Social sciences
Industrial administration
Medical
Advertising
Social work
Civil service
Armed forces
Buying
Hotel management and catering
Environmental control and design
Management services
Journalism
Management training
MA courses - Arts
Legal work
Banking
Insurance
Tourism
Stockbroking and investment analysis
MSc courses - Physical sciences
Teacher training
Entertainment

LIST 9.

Entertainment

Social work

Advertising

Legal work

MSc courses - Physical sciences

Insurance

Management services

Tourism

Public transport

Journalism

Quality control

Engineering

Local authority

Buying

Stockbroking and investment analysis

Civil service

Teacher training

Environmental control and design

Part-time education

Banking

Armed forces

Management training

Industrial administration

Medical

MSc courses - Social sciences

Retailing

Accountancy

Hotel management and catering

MA courses - Arts

PhD research

APPENDIX 4.4

SUBJECT INSTRUCTIONS

CONDITIONS 1 and 2

First of all you will undertake the training period. Please look away from the rig in front of you until instructed to turn towards it. When facing the rig you will notice that it consists of an array of labelled pigeon-holes. A list of job categories will be read to you which correspond to the labels on the pigeon-holes and you are required to touch each one heard. Upon completion of the list you should turn away from the pigeon-holes again. This procedure will then be repeated.

(Give the pile of information to them.)

The main experimental procedure will now be explained:-

In front of you you have a pile of sheets of information regarding student job opportunities. When instructed please turn over the top sheet, read it, and place it in the appropriate labelled pigeon-hole. If your choice is wrong the experimenter will say 'no' and you must then choose another appropriate pigeon-hole. A correct choice will evoke no response from the experimenter. This procedure should be repeated for each item of information until the pile is completed.

RECALL PROCEDURE

1. On the piece of paper provided can you please write down as many of the job categories as you can remember. Each time you finish a period of recall and have to think hard for more categories could you please draw a line.
2. (Give diagram of the pigeon-holes.) Could you please write the correct label, or what you think is the correct label, for each of the pigeon-holes on the diagram.

SUBJECT INSTRUCTIONS

CONDITION 3

First of all you will undertake the training period. Please look away from the rig in front of you until instructed to turn towards it. When facing the rig you will notice that it consists of an array of labelled pigeon-holes. A list of job categories will be read to you which correspond to the labels on the pigeon-holes and you are required to touch each one heard. Upon completion of the list you should turn away from the pigeon-holes again. This procedure will then be repeated.

(Give the pile of information to them.)

The main experimental procedure will now be explained:-

In front of you you have a pile of sheets of information regarding student job opportunities. When instructed please turn over the top sheet, read it, and place it in the appropriate labelled pigeon-hole. If your choice is wrong the experimenter will say 'no' and you must then choose another appropriate pigeon-hole. A correct choice will evoke no response from the experimenter. This procedure should be repeated for each item of information until the pile is completed.

RECALL PROCEDURE

1. (Give diagram of the pigeon-holes.) Could you please write the correct label, or what you think is the correct label, for each of the pigeon-holes on the diagram.

APPENDIX 4.5

Document A - Free recall by subject 8 in condition 2.

Banking	Quality control
Buying	
1 Retailing	Medical
2 Civil service	
1 Local authority	Public transport
2 Armed forces 3	
Advertising	Hotel and catering management
3 Insurance	
P-T education	~~Advertising~~--
4 MA arts	
5 MSc physical sciences	Legal work
6 MSc social sciences 4	
5 Engineering	

Social sciences

Environmental and pollution control

Teacher training

7 PhD courses

Journalism

8 Tourism

9 Entertainment

Management services

10 Management education

11 Industrial ....

Number recalled = 29

Number of pairs = 19

% categorical clustering = 10/19x100 (11)

= 52.6% (57.9)

% spatial clustering = 5/19x100

= 26.3%

Missed - Accountancy

{ denotes other possible associations.

MSc Physical Science	Journalism	Social Service	Banking	Buying
Teacher Training	Tourism	Civil Service	Insurance	Management Training
MSc Soc Science	Environmental Control and Design	Armed Forces	Accountancy	Management Services
MA Arts	Entertainment	Local Authority	Advertising	Industrial Admin
PhD Research	Hotel & catering	Medical	Stockbroking & Investment	Engineering
Part-time Courses	Legal Work	PUBLIC TRANSPORT (Forgotten)	Retailing	Quality Control
0 0 0 0 0 0	0 0 0 1 1 0	0 2 1 1 0 —	0 0 0 1 1 0	0 0 0 0 0 0

MSc Physical Sciences	Journalism	Social Work	Banking	Buying
Teacher Training	Tourism	Armed Forces	Insurance	Management Training
MSc Social Sciences	Environmental Control & Design	Local Authority	Accountancy	Management Services
MA Courses Arts	Hotel Management & Catering	Civil Service	Stockbroking & Investment Analysis	Industrial Administration
PhD Research	Entertainment	Medical	Advertising	Engineering
Part-time Education	Legal Work	Public Transport	Retailing	Quality Control

0 0 0 0 0 0 | 0 0 0 1 1 0 | 0 1 1 2 0 – | 0 0 0 1 1 0 | 0 0 0 0 0 0

APPENDIX 5.1

SUBJECT INSTRUCTIONS

First of all you will undertake the training period. When told to, please turn over the sheet of paper in front of you, on it is printed a list of job categories. A list of job categories will then be read to you which correspond to the ones on the list and you are required to point to each one in turn on your sheet. Upon completion of the list you should turn over the sheet of paper again. This procedure will then be repeated.

(Give them the pile of information)

The main experimental procedure will now be explained:-

I have placed in front of you a pile of sheets of information regarding student job opportunities. When instructed, please turn over the top sheet from the pile and also the sheet in front of you. You should read the sheet of information regarding the particular job opportunity and then decide which of the job categories on the list is most appropriate and tick it. If your choice is wrong the experimenter will say 'no' and you must delete your original choice and choose again. A correct choice will evoke no response from the experimenter. This procedure should be repeated for each item of information from the pile until they have all been classified.

RECALL PROCEDURE

Free recall: On the piece of paper provided can you please write down as many of the job categories as you can remember. Each time you finish a period of recall and have to think hard for more categories could you please draw a line.

Spatial recall:(Give subject the appropriate list template) Could you please write the correct job category, or what you think is the correct job category, in the appropriate position on this diagrammatic representation of the original list. Above each line corresponds to the position of a job category.

APPENDIX 5.2

DOCUMENT A - Scoring of categorical and spatial clustering in free-recall.

Sector projected from the number of categories remembered in the first six of the master list.

1 Engineering
2 Entertainment
categorical cluster 1 → 3 Social services ← 1 spatial cluster
4 Civil service
5 PhD research
2 →
6 MA Arts course
3 →
7 MSc Social sciences
4 →
8 MSc Physical sciences
5 →
9 Part time education
6 →
10 Teacher education

Sector division line.

11 Quality control
12 Environmental Design

---

13 Advertising
14 Buying
15 Retailing

16 Hotel management
17 Management training
7 →
18 Management services
19 Local authority
20 Insurance
21 Medical

22 Legal

---

23 Stockbroking
8 →
24 Banking

---

25 Tourism
26 Public transport

---

27 Journalism

No. rec.=27
pairs=22
cat. cluster=8/22=36.37%
spat. cluster=1/22=4.55%
%O=0%
%SS=8/27=29.63%
Total error=212
Ave. total error=7.85

DOCUMENT B - Master list with measures of spatial recall resulting the subject spatial recall shown in document C

1 • Part-time education O ✓
2 • Accountancy | ✓
3 • Quality control 6
4 • Local authority 3
5 • PhD research | ✓
6 • Retailing 2

Sector division line every six job categories.

7 • Public transport |
8 • Engineering 3
9 • MSc courses - Social sciences 2 ✓
10 Industrial administration

Would not be a numbered position if forgotten during free recall. This sector would therefore only contain no's 7-11, which would then be projected onto the free recall list for spatial scoring.

11 • Medical | ✓
12 • Advertising 2 ✓

13 • Social work 4 ✓
14 • Civil service O ✓
15 • Armed forces O ✓
16 • Buying 3 ✓
17 • Hotel management and catering 2
18 • Environmental control and design O ✓

19 • Management services | ✓
20 • Journalism | ✓
21 • Management training 5
22 • MA courses - Arts 3
23 Legal work
24 • Banking 2 ✓

25 • Insurance |
26 • Tourism 2 ✓
27 • Stockbroking and investment analysis | ✓
28 • MSc courses - Physical sciences | ✓
29 • Teacher training O ✓
30 • Entertainment O ✓

error score

Total error=48

Ave. total error=48/28=1.71

%SS=67.86 %O=21.43

✓ = In correct sector

DOCUMENT C - Spatial recall of the master list shown on document B

1 Part-time education

2

3 Accountancy

4 PhD

5 Engineering — spatial cluster

categorical cluster 1

6 Public transport — Sector division line.

7 Local authority

8 Retailing

9 Quality control

10 Advertising

11 MSc social

12 Medical

13 Buying

14 Civil service — 2

2

15 Armed forces

16 Management training

17 Social work

18 Environmental design — 3

3

19 Hotels

20 Management services — 4

21 Journalism

22 Banking

23

24 Insurance

25 MA

26 Stockbroking — 5

27 MSc - Physical sciences

28 Tourism

29 Teacher training — 6

30 Entertainment

No. recalled=28

Pairs=25

Cat. cluster=3/25=12

Spat. cluster=6/25=24

APPENDIX 5.3

Table 1. Experiment 2 - Number of categories recalled.

	CFR	CSR
S1	27	23
S2	28	29
S3	24	29
S4	28	26
S5	28	26
S6	21	28
S7	26	29
S8	24	29
S9	27	25
$\bar{x}$	25.89	27.11

Table 2. Experiment 2 - % categorical clustering.

	CFR %	CSR %
S1	36.36	25.00
S2	43.75	25.93
S3	40.00	18.52
S4	54.55	14.29
S5	32.00	31.82
S6	29.41	12.00
S7	52.17	7.41
S8	57.14	25.93
S9	34.78	15.79
$\bar{x}$	42.27	19.63

Table 3. Experiment 2 - % categorical clustering due to chance.

	CFR %	CSR %
S1	13.18	13.50
S2	14.38	15.68
S3	13.78	15.68
S4	13.18	13.33
S5	15.60	13.18
S6	13.53	15.60
S7	14.10	15.68
S8	14.52	15.68
S9	14.10	13.68
$\bar{x}$	14.04	15.01

Table 4. Experiment 2 - % spatial clustering.

	CFR %	CSR %
S1	4.55	25.00
S2	6.25	22.22
S3	13.33	37.04
S4	4.55	42.86
S5	16.00	36.36
S6	11.76	24.00
S7	8.60	14.81
S8	7.14	11.11
S9	13.04	10.53
$\bar{x}$	9.47	24.88

Table 5. Experiment 2 - % spatial clustering due to chance.

	CFR %	CSR %
S1	6.57	6.25
S2	6.60	6.48
S3	6.85	6.48
S4	6.57	6.35
S5	6.44	6.57
S6	6.37	6.44
S7	6.64	6.48
S8	6.35	6.48
S9	6.64	6.29
$\bar{x}$	6.56	6.42

Table 6. Experiment 2 - Total error and average total error.

	CFR		CSR	
	TOTAL ERROR	AVERAGE TE	TOTAL ERROR	AVERAGE TE
S1	212	7.85	58	2.52
S2	250	8.93	93	3.21
S3	110	4.58	39	1.34
S4	314	11.21	37	1.42
S5	224	8.0	60	2.31
S6	122	5.81	48	1.71
S7	210	8.1	66	2.28
S8	216	9.0	115	3.97
S9	182	6.74	93	3.72
$\bar{x}$	204.44	7.80	67.67	2.50

Table 7. Experiment 2 - Average total error due to chance.

	CFR-ATE	CSR-ATE
S1	12.15	12.42
S2	11.96	11.84
S3	12.39	11.84
S4	11.96	12.28
S5	11.96	12.28
S6	12.70	11.96
S7	12.28	11.84
S8	12.39	11.84
S9	12.15	12.41
$\bar{x}$	12.22	12.08

Table 8. Experiment 2 - % sector score.

	CFR%	CSR %
S1	29.63	65.22
S2	25.00	51.72
S3	20.83	72.41
S4	7.14	69.23
S5	32.14	65.38
S6	42.86	67.86
S7	34.62	65.51
S8	8.33	48.28
S9	37.04	60.00
$\bar{x}$	26.40	62.85

Table 9. Experiment 2 - % sector score due to chance.

	CFR %	CSR %
S1	17.70	18.00
S2	18.06	17.82
S3	18.06	17.82
S4	18.06	17.63
S5	18.06	17.63
S6	18.25	18.06
S7	17.63	17.82
S8	18.06	17.82
S9	17.70	17.67
$\bar{x}$	17.95	17.81

Table 10. Experiment 2 - %O score.

	CFR %	CSR %
S1	0	30.43
S2	10.71	17.24
S3	0	27.59
S4	3.57	42.31
S5	3.57	30.77
S6	9.52	21.43
S7	11.54	24.14
S8	0	20.69
S9	3.70	28.00
$\bar{x}$	4.73	26.96

Table 11. Experiment 2 - %O score due to chance.

	CFR %	CSR %
S1	3.91	4.23
S2	4.46	4.60
S3	4.17	4.60
S4	4.46	4.06
S5	4.46	4.06
S6	4.37	4.46
S7	4.06	4.60
S8	4.17	4.60
S9	3.91	4.11
$\bar{x}$	4.22	4.37

Table 12. <u>Experiment 2 - Times for training periods.</u>(mins)

	CFR			CSR		
	TR1	TR2	D	TR1	TR2	D
S1	1.98	1.97	0.01	2.03	1.73	0.40
S2	3.02	2.42	0.06	2.28	1.80	0.48
S3	3.35	2.68	0.67	1.55	1.42	0.13
S4	2.07	1.87	0.20	2.42	1.33	1.09
S5	2.35	2.35	0.00	2.12	1.57	0.55
S6	2.37	1.97	0.40	1.50	1.40	0.10
S7	2.62	1.93	0.69	2.47	2.22	0.25
S8	3.15	2.52	0.63	2.27	2.22	0.05
S9	1.97	1.92	0.05	2.83	2.62	0.21
	2.54	2.18	0.36	2.16	1.81	0.36

Table 13. <u>Experiment 2 - Times for experimental periods.</u>(mins)

	CFR	CSR
S1	46.27	35.50
S2	33.72	37.28
S3	49.95	31.12
S4	28.13	26.75
S5	29.50	36.10
S6	60.28	17.13
S7	27.70	33.97
S8	38.88	32.32
S9	31.75	49.34
	38.46	33.28

Table 14. Experiment 3 - Number of categories recalled.

	FR	SR
S1	26	28
S2	27	23
S3	28	28
S4	26	26
S5	25	25
S6	27	20
S7	25	24
S8	23	28
S9	27	25
$\bar{x}$	26	25.22

Table 15. Experiment 3 - % categorical clustering.

	CFR %	CSR %
S1	50.0	22.7
S2	41.18	18.75
S3	38.9	4.55
S4	50	15
S5	33.3	23.5
S6	34.8	16.66
S7	42.11	6.25
S8	50	18.2
S9	43.48	11.8
$\bar{x}$	42.63	15.27

Table 16. Experiment 3 - % categorical clustering due to chance.

	CFR %	CSR %
S1	14.38	13.18
S2	13.53	14.38
S3	12.96	13.18
S4	12.96	13.50
S5	13.78	13.53
S6	14.10	11.94
S7	13.68	14.38
S8	13.50	13.18
S9	14.10	13.53
$\bar{x}$	13.67	13.42

Table 17. Experiment 3 - % spatial clustering.

	CFR %	CSR %
S1	12.5	27.3
S2	11.76	25.00
S3	16.67	22.73
S4	5.56	60.0
S5	0	17.6
S6	8.7	33.33
S7	10.53	37.50
S8	10	50
S9	0	5.9
$\bar{x}$	8.41	31.04

Table 18. Experiment 3 - % spatial clustering due to chance.

	CFR %	CSR %
S1	6.60	6.57
S2	6.37	6.60
S3	6.02	6.57
S4	6.02	6.25
S5	6.85	6.37
S6	6.64	6.94
S7	6.29	6.60
S8	6.25	6.57
S9	6.64	6.37
$\bar{x}$	6.41	6.54

Table 19. Experiment 3 - Total error and average total error.

	CFR		CSR	
	TOTAL ERROR	AVERAGE TE	TOTAL ERROR	AVERAGE TE
S1	194	7.46	59	2.11
S2	235	8.70	83	3.61
S3	258	9.21	79	2.82
S4	194	7.46	36	1.38
S5	232	9.28	40	1.60
S6	162	6.00	63	3.15
S7	242	9.68	48	2.00
S8	216	9.39	40	1.43
S9	285	10.56	73	2.92
$\bar{x}$	224.22	8.64	57.89	2.34

Table 20. Experiment 3 - Average total error due to chance.

	CFR-ATE	CSR-ATE
S1	12.28	11.96
S2	12.15	12.42
S3	11.96	11.96
S4	12.28	12.28
S5	12.41	12.41
S6	12.15	12.83
S7	12.41	12.39
S8	12.42	11.96
S9	12.15	12.41
$\bar{x}$	12.25	12.29

Table 21. Experiment 3 - % sector score.

	CFR %	CSR %
S1	23.08	75.00
S2	22.22	69.57
S3	25.00	67.86
S4	34.62	92.31
S5	8.33	80.00
S6	29.60	60.00
S7	16.00	83.33
S8	21.74	78.57
S9	18.52	52.00
$\bar{x}$	22.12	73.18

Table 22. Experiment 3 - % sector score due to chance.

	CFR %	CSR %
S1	17.63	18.06
S2	17.70	18.00
S3	18.06	18.06
S4	17.63	17.63
S5	17.67	17.67
S6	17.70	17.92
S7	17.67	18.06
S8	18.00	18.06
S9	17.70	17.67
$\bar{x}$	17.75	17.90

Table 23. Experiment 3 - %O score.

	CFR %	CSR %
S1	3.85	32.14
S2	11.11	43.48
S3	7.14	42.86
S4	3.85	57.70
S5	12.00	40.00
S6	7.40	20.00
S7	4.00	37.50
S8	4.35	57.14
S9	0	28.00
$\bar{x}$	5.97	39.90

Table 24. Experiment 3 - %O score due to chance.

	CFR %	CSR %
S1	4.06	4.46
S2	3.91	4.23
S3	4.46	4.46
S4	4.06	4.06
S5	4.11	4.11
S6	3.91	4.44
S7	4.11	4.17
S8	4.23	4.46
S9	3.91	4.11
$\bar{x}$	4.08	4.28

Table 25. Experiment 3 - Times for training periods.(mins)

	FR			SR		
	TR1	TR2	D	TR1	TR2	D
S1	2.13	2.00	0.13	2.7	1.98	0.72
S2	1.78	1.50	0.28	2.67	2.00	0.67
S3	2.88	1.93	0.19	2.75	2.67	0.08
S4	3.68	2.25	1.43	2.50	1.97	0.53
S5	2.10	2.18	-0.08	1.75	1.62	0.13
S6	2.97	2.03	0.96	3.16	2.25	0.91
S7	2.70	1.83	0.87	2.92	1.98	0.94
S8	1.25	2.47	-1.22	2.75	1.97	0.78
S9	1.95	1.88	0.07	2.77	3.08	-0.31
$\bar{x}$	2.38	2.01	0.29	2.66	2.17	0.49

Table 26. Experiment 3 - Times for experimental periods.(mins)

	FR	SR
S1	45.53	43.37
S2	38.40	55.53
S3	35.43	44.12
S4	37.60	26.33
S5	51.31	34.45
S6	30.75	42.62
S7	42.38	41.95
S8	40.42	33.40
S9	40.00	35.40
$\bar{x}$	40.20	39.69

Table 27. Experiment 4 - Number of categories recalled.

	CFR	CSR
S1	25	27
S2	26	26
S3	22	27
S4	30	28
S5	27	25
S6	28	29
S7	28	25
S8	27	24
S9	24	26
$\bar{x}$	26.33	26.33

Table 28. Experiment 4 - % categorical clustering.

	CFR	CSR
S1	47.1	100.00
S2	60.00	88.90
S3	50.00	95.00
S4	74.1	100.00
S5	75.00	100.00
S6	52.00	86.96
S7	47.83	100.00
S8	40.00	37.5
S9	68.18	68.42
$\bar{x}$	57.13	86.31

Table 29. Experiment 4 - % categorical clustering due to chance.

	CFR	CSR
S1	13.53	13.68
S2	13.50	12.96
S3	12.96	13.50
S4	15.68	13.18
S5	14.86	13.53
S6	15.60	14.10
S7	14.10	12.96
S8	13.50	14.38
S9	13.18	12.96
$\bar{x}$	14.1	13.47

Table 30. Experiment 4 - % spatial clustering.

	CFR	CSR
S1	17.65	78.95
S2	30.00	72.22
S3	27.78	65.00
S4	40.74	90.91
S5	33.33	88.24
S6	32.00	73.91
S7	21.74	66.67
S8	15.00	25.00
S9	40.91	52.63
$\bar{x}$	28.93	68.17

Table 31. Experiment 4 - % spatial clustering due to chance.

	CFR	CSR
S1	6.37	6.29
S2	6.25	6.02
S3	6.02	6.25
S4	6.48	6.57
S5	6.71	6.37
S6	6.44	6.64
S7	6.64	6.02
S8	6.25	6.60
S9	6.57	6.29
$\bar{x}$	6.41	6.34

Table 32. Experiment 4 - Total error and average total error.

	CFR		CSR	
	TE	ATE	TE	ATE
S1	234	9.36	5	0.19
S2	131	5.04	27	1.04
S3	98	4.45	11	0.41
S4	84	2.47	2	0.071
S5	148	5.48	3	0.12
S6	224	8.00	14	0.48
S7	298	10.64	14	0.56
S8	176	6.52	87	3.625
S9	26	1.08	63	2.42
$\bar{x}$	157.6	4.83	25.11	1.0

Table 33. Experiment 4 - Average total error due to chance.

	CFR	CSR
	ATE	ATE
S1	12.41	12.15
S2	12.28	12.28
S3	12.52	12.15
S4	11.69	11.96
S5	12.15	12.41
S6	12.41	11.84
S7	11.96	12.41
S8	12.15	12.39
S9	12.39	12.28
$\bar{x}$	12.22	12.21

Table 34. Experiment 4 - % sector score.

	CFR	CSR
S1	28.00	100.00
S2	30.77	92.31
S3	54.55	96.30
S4	73.33	100.00
S5	37.04	100.00
S6	32.14	93.10
S7	10.71	100.00
S8	37.04	62.5
S9	75.00	65.38
$\bar{x}$	42.04	89.95

Table 35. Experiment 4 - % sector score due to chance.

	CFR	CSR
S1	17.67	17.70
S2	17.63	17.63
S3	18.06	17.70
S4	17.96	18.06
S5	17.70	17.67
S6	17.67	17.82
S7	18.06	17.67
S8	17.70	18.06
S9	18.06	17.63
$\bar{x}$	17.83	17.77

Table 36. Experiment 4 - %O score.

	CFR	CSR
S1	0	81.48
S2	7.69	69.23
S3	4.55	70.37
S4	26.67	92.86
S5	3.70	92.00
S6	7.14	68.97
S7	0	64.00
S8	7.41	25.00
S9	45.83	57.69
$\bar{x}$	11.44	69.07

Table 37. Experiment 4 - %O score due to chance.

	CFR	CSR
S1	4.11	3.91
S2	4.06	4.06
S3	4.29	3.91
S4	4.63	4.46
S5	3.91	4.11
S6	4.11	4.60
S7	4.46	4.11
S8	3.91	4.17
S9	4.17	4.06
$\bar{x}$	4.18	4.15

Table 38. Experiment 4 - Times for training periods.(mins)

	CFR			CSR		
	TR1	TR2	D	TR1	TR2	D
S1	2.42	1.85	0.57	1.92	1.53	0.39
S2	1.82	1.37	0.45	3.07	1.83	1.24
S3	2.58	1.90	0.68	2.18	1.50	0.68
S4	1.97	1.53	0.44	1.68	1.58	0.10
S5	1.93	1.25	0.68	2.12	1.62	0.50
S6	2.37	1.55	0.82	2.12	1.45	0.67
S7	3.92	2.75	1.17	2.65	1.98	0.67
S8	2.90	2.67	0.23	2.15	2.17	-0.02
S9	2.05	1.65	0.40	1.85	1.40	0.45
$\bar{x}$	2.44	1.84	0.64	2.19	1.67	0.52

Table 39. Experiment 4 - Times for experimental periods.(mins)

	CFR	CSR
S1	47.00	26.50
S2	31.32	54.63
S3	45.25	29.50
S4	27.83	24.43
S5	20.67	25.50
S6	24.48	27.73
S7	50.58	40.18
S8	53.38	46.42
S9	31.90	36.50
$\bar{x}$	36.93	34.60

Table 40. Experiment 5 - Number of categories recalled.

	CFR	CSR
S1	23	27
S2	23	26
S3	27	27
S4	28	29
S5	27	27
S6	28	28
S7	28	30
S8	28	26
S9	29	25
$\bar{x}$	26.78	27.22

Table 41. Experiment 5 - % categorical clustering.

	CFR	CSR
S1	40.00	76.19
S2	44.44	88.89
S3	68.75	100.00
S4	50.00	82.61
S5	61.90	95.00
S6	66.67	69.57
S7	50.00	100.00
S8	69.23	78.95
S9	77.27	83.33
$\bar{x}$	58.70	86.06

Table 42. Experiment 5 - % categorical clustering due to chance.

	CFR	CSR
S1	13.78	13.33
S2	12.96	12.96
S3	14.38	13.33
S4	13.50	14.10
S5	13.33	13.50
S6	14.86	14.10
S7	13.18	15.60
S8	16.15	13.68
S9	13.18	12.96
$\bar{x}$	13.92	13.73

Table 43. Experiment 5 - % spatial clustering.

	CFR %	CSR %
S1	26.70	76.19
S2	22.22	88.89
S3	31.25	95.24
S4	15.00	82.61
S5	28.57	85.00
S6	25.00	43.48
S7	22.73	56.00
S8	38.46	57.89
S9	22.72	66.67
$\bar{x}$	25.85	72.44

Table 44. Experiment 5 - % spatial clustering due to chance

	CFR %	CSR %
S1	6.85	6.35
S2	6.02	6.02
S3	6.60	6.35
S4	6.25	6.64
S5	6.35	6.25
S6	6.71	6.64
S7	6.57	6.44
S8	6.52	6.29
S9	6.57	6.02
$\bar{x}$	6.49	6.35

Table 45. Experiment 5 - Total error and average total error.

	CFR	CSR
S1	9.09	0.70
S2	8.26	0.31
S3	10	0.15
S4	9.61	4.83
S5	4.89	0.11
S6	8.61	1.86
S7	9.07	0.43
S8	4.21	1.08
S9	6.14	2.40
$\bar{x}$	7.76	1.32

Table 46. Experiment 5 - Average total error due to chance.

	CFR	CSR
S1	12.42	12.15
S2	12.42	12.42
S3	12.15	12.15
S4	11.96	11.84
S5	12.15	12.15
S6	11.96	11.96
S7	11.96	11.69
S8	11.96	12.28
S9	11.84	12.41
$\bar{x}$	12.09	12.12

Table 47. Experiment 5 - % sector score.

	CFR	CSR
S1	17.39	85.19
S2	30.43	96.15
S3	11.11	100.00
S4	10.71	93.10
S5	40.74	96.30
S6	21.43	82.14
S7	42.86	100.00
S8	64.29	88.46
S9	44.83	68.00
$\bar{x}$	31.53	89.93

Table 48. Experiment 5 - % sector score due to chance.

	CFR	CSR
S1	18.00	17.70
S2	18.00	18.00
S3	17.70	17.70
S4	18.06	17.82
S5	17.70	17.70
S6	18.06	18.06
S7	18.06	17.96
S8	18.06	17.63
S9	17.82	17.67
$\bar{x}$	17.94	17.80

Table 49. Experiment 5 - %0 score.

	CFR	CSR
S1	0.00	81.48
S2	4.35	84.62
S3	3.70	88.89
S4	0.00	93.10
S5	7.41	88.89
S6	7.14	57.14
S7	21.43	66.67
S8	3.57	73.08
S9	3.45	60.00
$\bar{x}$	5.67	77.10

Table 50. Experiment 5 - %0 score due to chance.

	CFR	CSR
S1	4.23	3.91
S2	4.23	4.23
S3	3.91	3.91
S4	4.46	4.60
S5	3.91	3.91
S6	4.46	4.46
S7	4.46	4.63
S8	4.46	4.06
S9	4.60	4.11
$\bar{x}$	4.30	4.20

Table 51. Experiment 5 - Times for training periods. (mins)

	CFR			CSR		
	Tr1	Tr2	D	Tr1	Tr2	D
S1	1.75	1.27	0.48	1.72	1.33	0.39
S2	2.67	2.28	0.49	2.33	1.83	0.50
S3	1.91	1.40	0.51	2.42	1.70	0.72
S4	1.20	1.12	0.08	1.53	1.25	0.28
S5	1.53	1.17	0.40	2.63	1.87	0.76
S6	1.88	1.50	0.38	2.17	1.33	0.84
S7	1.55	1.23	0.32	1.60	1.40	0.20
S8	2.00	1.70	0.30	1.57	1.42	0.15
S9	1.55	1.25	0.30	2.25	1.35	0.90
$\bar{x}$	1.78	1.44	0.36	2.03	1.50	0.53

Table 52. Experiment 5 - Times for experimental periods. (mins)

	CFR	CSR
S1	26.72	28.25
S2	60.72	42.38
S3	32.38	55.45
S4	19.00	32.46
S5	25.75	32.12
S6	22.65	18.20
S7	35.25	25.57
S8	22.80	24.03
S9	18.56	22.25
$\bar{x}$	29.31	31.19

APPENDIX 7.1

APPENDIX 7.1

Subject Instructions

A. You have been asked to check faults in a computerised dictionary. Each word is stored with a code number, your task is to determine whether the code numbers accompanying the words on a paper based index are the same as those in the computer store.

When I run the program the computer will display words on the screen one at a time. You will be given an index which contains the words displayed. You should use this to formulate the appropriate code number and then input it into the computer to check its authenticity.

Show document 1) for 2-level index and 2) for 4-level.

2-level (document 1)

The index consists of five general categories and they each contain appropriate related words. When a word appears on the screen, I would like you to locate the appropriate general category (point to on the general example). You will see that it is directly preceded by a number. I would like you to type this number on the numerical keyboard on the right of the computer, and then pronounce the general category aloud. You should then locate the word that was projected on to the screen and similarly input the associated number and repeat the word aloud as before. You should then press 'return' (indicate). (Now run through the specific example.) Please work quickly and efficiently, making as few errors as possible.

4-level (document 2)

The index consists of five general categories, each of which is subdivided into three further related levels of classification. When a word appears on the screen, I would like you to locate the appropriate general category (point to on the general example). You will see that it is directly preceded by a number. I would like you to type this number on the numerical keyboard on the right of the computer, and then pronounce the general category aloud. You should then repeat this procedure for the sub-ordinate levels (indicate) until you have completed all the levels, including the word originally shown, making sure that you repeat each word aloud. You should then press "return". (Now run through the specific example). Please work quickly and efficiently, making as few errors as possible.

Show document 3: The five general categories are as follows: (read them out).

I must stress the importance of pressing the 'return' key, the computer will not recognise your input until you do so.

If your input is correct, the computer will display "CORRECT! TYPE 'Y' WHEN YOU ARE READY FOR THE NEXT WORD"; you should proceed accordingly.

If your input is incorrect, the computer will display "INCORRECT CODE NUMBER , TRY AGAIN! THE CODE NUMBER IS: ?"; you should then use the index again, as before, to input the correct number.

When you have completed all the words the computer will display "END OF EXPERIMENT".

B. You should carry out the task as before but this time you do not have to repeat the words aloud. The important factor is to input the correct code numbers. Please work quickly and efficiently, making as few errors as possible.

C. As happened yesterday, the computer will display words one at a time. If a word is one that you coded using the index press "Y" for yes; if it wasn't a word you coded press "N" for no. Please work quickly and efficiently, making as few errors as possible.

Document 1.

EXAMPLE OF THE LAYOUT OF THE EXPERIMENTAL WORD INDEX

8. GENERAL CATEGORY

619. word
612. word
245. word
249. word

EXAMPLE

8. ANIMAL

619. Gorilla
612. Chimpanzee
245. Haddock
249. Mackerel

Document 2.

EXAMPLE OF THE LAYOUT OF THE EXPERIMENTAL WORD INDEX

8. GENERAL CATEGORY

    6. 1ST SUBDIVISION

        1. 2nd subdivision - 9. word
                             2. word

    2. 1ST SUBDIVISION

        4. 2nd subdivision - 5. word
                             9. word

EXAMPLE.

8. ANIMAL

    6. MAMMAL

        3. Ape - 9. Gorilla
                 6. Chimpanzee

    2. FISH

        4. Sea - 5. Haddock
                 9. Mackerel

Document 3.

EXPERIMENTAL GENERAL CATEGORIES.

There are five general experimental categories:

1. COMPARISON
2. DIMENSIONS
3. FORM
4. MOTION
5. HUMAN ATTRIBUTES

APPENDIX 7.2

```
1 DATA CORRESPONDENCE,Y,INTERDEPENDENCE,Y
2 DATA DISSIMILARITY,Y,UNLIKENESS,Y
3 DATA DIVERSITY,Y,RESEMBLANCE,Y
4 DATA SEMBLANCE,Y,CHANGE,Y
5 DATA ALTERATION,Y,IMITATION,Y
6 DATA REPRODUCTION,Y,REMOTENESS,Y
7 DATA FARNESS,Y,MAGNITUDE,Y
8 DATA VOLUME,Y,CAPACITY,Y
9 DATA ALTITUDE,Y,ELEVATION,Y
10 DATA LONGITUDE,Y,MILEAGE,Y
11 DATA ROUNDNESS,Y,ROTUNDITY,Y
12 DATA ANGLE,Y,CORNER,Y
13 DATA SMOOTHNESS,Y,LEVEL,Y
14 DATA CORRUGATION,Y,TEXTURE,Y
15 DATA SWIFTNESS,Y,SPEED,Y
16 DATA DAWDLE,Y,LINGER,Y
17 DATA PROPULSION,Y,IMPETUS,Y
18 DATA REPULSION,Y,REBOUND,Y
19 DATA RISING,Y,UPGROWTH,Y
20 DATA CLIMB,Y,DRIFT,Y
21 DATA DEFLECTION,Y,GRATIFICATION,Y
22 DATA ENJOYMENT,Y,CONTENTEDNESS,Y
23 DATA SATISFACTION,Y,SERENITY,Y
24 DATA DEPRESSION,Y,SADNESS,Y
25 DATA ELEGANCE,Y,GRACE,Y
26 DATA REFINEMENT,Y,CONOISSEUR,Y
27 DATA RESPONSIBILITY,Y,LIABILITY,Y
28 DATA JUSTICE,Y,LEGALITY,Y
29 DATA REGARD,Y,COURTESY,Y
30 DATA SCORN,Y,DERISION,Y
40 DATA COMBINATION,N,UNION,N
42 DATA BLEND,N,MIXTURE,N
44 DATA EQUALITY,N,BALANCE,N
46 DATA PARITY,N,MISMATCH,N
48 DATA CONTINUITY,N,ORDER,N
50 DATA REGULARITY,N,UNIFORMITY,N
52 DATA CONFORMITY,N,CONCURRENCE,N
54 DATA COUNTERACTION,N,REPETITION,N
55 DATA CLASS,N,SPACE,N
56 DATA EXPANSE,N,DISPLACEMENT,N
58 DATA BOUNDARY,N,LIMIT,N
60 DATA CONFINE,N,BREADTH,N
62 DATA THICKNESS,N,INTERVAL,N
63 DATA DEPTH,N,JOURNEY,N
64 DATA LOCOMOTION,N,DRIVE,N
66 DATA CONVERGENCE,N,DEPARTURE,N
68 DATA START,N,LEAP,N
69 DATA SYMMETRY,N,OUTLINE,N
70 DATA SHAPLINESS,N,PROPORTION,N
72 DATA DISTORTION,N,DEFORMITY,N
73 DATA EDGE,N,SHARPNESS,N
74 DATA SENSIBILITY,N,EXCITABILITY,N
76 DATA BRAVERY,N,RASHNESS,N
78 DATA VALOR,N,EXPECTANCE,N
80 DATA COMPOSURE,N,FRIENDSHIP,N
82 DATA AMITY,N,BROTHERHOOD,N
84 DATA FORGIVENESS,N,PARDON,N
86 DATA WORSHIP,N,DEVOTION,N
88 DATA PIETY,N,RELIGION,N
90 DATA PITY,N,VICE,N
100 DIM A$(120),B$(120),C$(120),W$(120)
```

```
110 DIM T(120),C(120)
200 FOR I=1 TO 120
210 READ A$(I),B$(I)
220 NEXT I
500 FOR K=1 TO 120
510 PRINT"3"
520 X=INT(RND(1)*120)+1
550 IFA$(X)="0" THEN GOTO 520
560 W$(X)=A$(X)
570 A$(X)="0"
580 PRINT"THE WORD IS:  ";W$(X)
590 PRINT""
600 PRINT"WAS THIS ONE OF THE WORDS THAT YOU       CHECKED?"
605 PRINT""
610 PRINT"PLEASE TYPE 'Y' FOR YES, OR 'N'          FOR NO"
620 TI$="000000"
650 GET Z$:IF Z$="" THEN GOTO 650
655 GOTO 660
660 T=TI/60
661 T=INT(T*100+0.5)/100
665 T(X)=T
667 C(X)=K
670 IF Z$=B$(X) THEN GOTO 700
680 IF B$(X)="N" THEN C$(X) ="FA"
690 IF B$(X)="Y" THEN C$(X) ="MISS"
695 GOTO 800
700 IF B$(X)="Y" THEN C$(X)="HIT"
710 IF B$(X)="N" THEN C$(X)="CR"
800 NEXT K
802 PRINT"3"
805 PRINT""
810 PRINT"FOR RESULTS TYPE 'DATA'"
820 INPUT D$:IF D$="DATA" THEN GOTO 850
850 OPEN 4,4:CMD 4
860 PRINT"WORD","STATUS","ANSWER","TIME"
900 FOR J=1 TO 120
920 WO=15-LEN(W$(J))
1040 PRINT C(J);W$(J);SPC(WO),B$(J),C$(J),T(J)
1045 NEXT J
1050 F=0
1051 SF=0
1060 FOR J=1 TO 120
1070 F=T(J)+F
1080 SF=T(J)*T(J)+SF
1090 NEXT J
1100 PRINT "AVERAGE=";F/120,"SF↑2=";SF,"(SF)↑2=";SF*SF
2000 PRINT#4:CLOSE4
2010 STOP
READY.
```

```
2 DATA CORRESPONDENCE,8615,INTERDEPENDENCE,8612
5 DATA DISSIMILARITY,8691,UNLIKENESS,8699
8 DATA DIVERSITY,8697,RESEMBLANCE,8362
11 DATA SEMBLANCE,8365,CHANGE,8385
14 DATA ALTERATION,8389,IMITATION,8393
17 DATA REPRODUCTION,8397,REMOTENESS,5959
20 DATA FARNESS,5951,MAGNITUDE,5985
23 DATA VOLUME,5982,CAPACITY,5986
26 DATA ALTITUDE,5828,ELEVATION,5822
29 DATA LONGITUDE,5819,MILEAGE,5815
32 DATA ROUNDNESS,6561,ROTUNDITY,6569
35 DATA ANGLE,6582,BEND,6584
36 DATA CORNER,6589,SMOOTHNESS,6678
37 DATA LEVEL,6672
38 DATA CORRUGATION,6682,TEXTURE,6689
41 DATA SWIFTNESS,2647,SPEED,2649
44 DATA DAWDLE,2693,LINGER,2695
47 DATA PROPULSION,2826,THRUST,2821
50 DATA IMPETUS,2829,REPULSION,2814
53 DATA REBOUND,2813,RISING,2143
56 DATA UPGROWTH,2144,CLIMB,2148
59 DATA DRIFT,2181,DEFLECTION,2189
62 DATA GRATIFICATION,1851,ENJOYMENT,1852
65 DATA CONTENTEDNESS,1867,SATISFACTION,1866
68 DATA SERENITY,1868,DEPRESSION,1829
71 DATA SADNESS,1825,ELEGANCE,1614
74 DATA GRACE,1613,REFINEMENT,1696
77 DATA CONNOISSEUR,1697,RESPONSIBILITY,1746
80 DATA LIABILITY,1749,JUSTICE,1796
83 DATA LEGALITY,1793,REGARD,1139
86 DATA COURTESY,1135,SCORN,1143
89 DATA DERISION,1141
100 DIM A$(62),B(62),L(62),E$(62)
110 DIM G(62,5),S(62,5),N(62)
115 DIM Q$(62),P(62),D(62),NN(62)
120 FOR Z=1 TO 62
130 READ A$(Z),B(Z)
140 NEXT Z
150 Z$="20>:??:9??8=9;004<31>6"
160 FOR I=1 TO LEN(Z$) /2
170 POKE I+844,ASC(MID$(Z$,I*2-1))*16+ASC(MID$(Z$,I*2))-816:NEXT I
180 POKE 144,77:POKE145,3
200 FOR K=1 TO 62
205 V=0
210 PRINT"3"
220 F=INT(RND(1)*62)+1
225 IF A$(F)="0" THEN GO TO 220
230 H$=A$(F)
240 E$(F)=A$(F)
245 Q$(K)=A$(F)
250 A$(F)="0"
260 PRINT""
310 PRINT"THE WORD IS:  ",H$
320 PRINT
330 PRINT"PLEASE ENTER THE CORRECT CODE NUMBER    (RETURN)"
340 PRINT
345 TI$="000000"
350 INPUT"THE CODE NUMBER IS: ";C
380 T=TI/60
381 T=INT(T*100+0.5)/100
385 PRINT
390 IF C=B(F) THEN GO TO 500
405 S(F,V)=C
410 G(F,V)=T
420 V=V+1
425 IF V=5 THEN GOTO 435
```

```
427 PRINT"INCORRECT CODE NUMBER,TRY AGAIN!"
430 GO TO 350
435 N(F)=K
440 PRINT"5 ERRORS, TYPE IN 'Y' TO CONTINUE"
450 GET X$:IF X$="" THEN 450
455 GOTO 600
500 L(F)=T
502 P(K)=T
503 D(K)=C
505 N(F)=K
507 NN(K)=K
510 PRINT"CORRECT!"
520 PRINT
530 PRINT"TYPE 'Y' WHEN YOU ARE READY FOR         THE NEXT WORD"
540 GET J$:IF J$="" THEN 540
545 IF J$="YES" THEN GO TO 600
600 NEXT K
650 PRINT"3"
700 PRINT"THE EXPERIMENT IS OVER, ENTER 'DATA' FOR RESULTS"
710 INPUT Z$:IF Z$="DATA" THEN GOTO 730
730 OPEN 4,4:CMD4
750 PRINT"THE TIMES FOR THE CORRECT CODINGS ARE AS FOLLOWS:"
760 PRINT"    WORD","      CODE","          TIME"
800 FOR I=1 TO 62
810 PRINT N(I);E$(I),B(I),L(I)
820 NEXT I
830 PRINT
850 PRINT"IN PRESENTATION ORDER"
860 FOR I=1 TO 62
870 PRINTNN(I);Q$(I),D(I),P(I)
880 NEXT I
900 PRINT"THE TIMES FOR THE INCORRECT CODINGS ARE AS FOLLOWS:"
910 PRINT"WORD","CODE","TIME"
920 FOR J=1 TO 62
930 FOR U=0 TO 4
940 IFS(J,U)=0 THEN GOTO 960
945 IF G(J,U)=0 THEN GOTO 960
950 PRINT E$(J),S(J,U),G(J,U)
960 NEXT U
970 NEXT J
980 X=0
985 SX=0
990 FOR I=1 TO 62
1000 X=L(I)+X
1005 SX=L(I)*L(I)+SX
1010 NEXT I
1020 PRINT"AVERAGE=";X/62,"SX↑2=";SX,"(SX)↑2=";X*X
1040 PRINT#4:CLOSE4
1045 POKE 144,77:POKE 145,3
1050 STOP
READY.
```