# Progress Report 1981-1984

## 1. SUMMARY (Directors Overview)

Much of the Unit's theoretical work falls within the area that could loosely be called mainstream cognitive psychology. This includes work on memory, language, reading and reasoning, together with the breakdown in these functions in neuropsychological patients or patients suffering from psychiatric or emotional problems. The concept of working memory, for example was originally developed within the laboratory using normal subjects to study the temporary storage of information in connection with other cognitive tasks. It has subsequently been extended to account for data from neuropsychological patients while the model is providing a useful framework for studying problems ranging from normal and dyslexic reading, to disruption of memory by unwanted sound and from memory for music to senile dementia. Much of the Unit's work in long-term memory 1s concerned with research outside the laboratory, although this often has theoretical implications. A good example of this is our research on eyewitness testimony which has produced results which have both practical implications for the questioning of witnesses, and theoretical implications for the nature of the underlying memory trace.

In our last progress report we stated an aim of increasing the Unit's work in the area of language and speech, and have succeeded in doing so. Prosody and the role of stress and timing in speech production is a particularly active area at present; work In this area has considerable Implications for computer-based speech processing, and collaborative work includes two projects funded by British Telecom and participation 1n an Alvey-sponsored project as part of a consortium that involves the Linguistics and Engineering departments of the University together with Acorn Computers and Standard Telephone and Cables.

Research on reading and writing continues to play an important role in the work of the Unit, and work on the breakdown of these skills In brain damaged patients is continuing to prove extremely fruitful. The principal strategy is still to attempt to relate the breakdown of function in patients to models of normal cognition. The emphasis has shifted somewhat from deep dyslexia which was the most extensively studied deficit described 1n the previous progress report to surface and phonological dyslexia, and to deficits of writing and spelling. The Unit 1s continuing to play a very active role in the development of cognitive theory. Johnson-Laird's mental models approach is clearly likely to be highly influential, while the Unit continues to have an active interest in the application of artificial Intelligence to cognitive psychology. Unfortunately however this is one area that, despite its timeliness and importance, is unlikely to continue to flourish unless up-to-date computing facilities can be made available.

A major new development has been the attempt to apply the techniques of cognitive psychology to clinical problems of patients with psychiatric and emotional problems. The Unit has formed excellent links with NHS clinical colleagues, and is carrying out research on a range of populations, some involving patients such as depressives or suicide attempters, others using subsamples of the general population with milder emotional problems such as spider phobia, excessive worrying, or loneliness. Preliminary results indicate that this is a viable enterprise both logistically and scientifically. The speed with which this small group has established itself, and its success in interacting with both clinical and cognitive colleagues is very gratifying.

A central component of the Unit's work involves the application of cognitive psychology to the tackling of practical questions, an area which could loosely be termed Cognitive Ergonomics. The development of new computer-based technology raises many problems of relating the computer to the human user, and on a worldwide basis is certainly the major growth area of applied psychology. Having worked in this area for over a decade, the APU is in a good position both to attract outside support and to ensure that its findings reach the potential user.

Much of our work has been concerned with the development of computer-based office systems, where ease and efficiency of use depends crucially on taking account of the user's "mental model" of the system, which will almost certainly differ radically from the mental model of the expert computer scientist who created the system. Similar problems occur in the design of programming languages, in the organisation and structure of information retrieval systems such as Prestel and Viewdata, and in the design and development of expert systems.

Expert systems attempt to take the information possessed by an expert in a particular field, and embody this in a computer-based system. While the computer science techniques are advancing rapidly in this area, a crucial stumbling block is likely to be the problem of how to "harvest" an expert's knowledge, a question closely related to the psychological problem of exploring an individual's semantic memory. Research on this important but difficult topic is beginning, in collaboration with British Telecom, and with Unilever. We are continuing to carry out work on more traditional methods of information transmission, with ongoing research concerned with the design of forms, tables, leaflets and instructions, all topics on which we are frequently asked for advice and assistance. A new development in this area is our attempt to move from the identification of problems in written material to an exploration of possible methods of improving the quality of writing so as to avoid the occurrence of such problems.

The project concerned with accidents has completed one cycle of research and is beginning a second. The phase that is virtually complete involved investigating claims that particular psychological variables were predictive of future accidents. Studies included work on bus drivers and pilots, and the measures included both field dependence, the capacity for perceiving a pattern against a jumbled background, and an attentional flexibility measure. Neither proved-adequate predictors. At a theoretical level two influential concepts, that of risk homeostasis, and that of perceptual style have been critically evaluated and related to the problem of accidents.

Another application of cognitive psychology is to the monitoring of human performance under stress. Both the main Unit and the Psychophysiology section continue to be concerned with the development of tools for assessing performance, and in recent years these have been applied, to the effects on performance of the fear induced in novice parachutists, and novice colloquium speakers, to the effects of breathing mixture on deep divers, to studies of noise, sleep deprivation and to the side-effects of drugs.

Research in the area of hearing has been very successful over the last three years. It may be recalled that work on the discrimination of sounds in noise gave rise to a detailed model of the auditory filter. This was then used both to produce improved audiometric techniques, and to design auditory warnings for specific environments. Guidelines for the design and evaluation of auditory warnings have been produced for the Civil Aviation Authority and warnings have been produced for the BAC 1-11, the Boeing 747 and for military helicopters. The work has been patented and has so far generated some £20,000. Current developments include the application of this research to the production of international standards for auditory warnings in hospitals.

A potentially extremely important development from this research is the spiral model of hearing. This involves the proposal of a spiral mechanism for the rapid and accurate categorisation of sound patterns. The model accounts for the characteristic features of musical perception, and has the further advantage that it offers an extremely promising design for a computer-based speech recognition system. The system has been patented with the help of the Industrial Liaison Group, and a venture capital company has agreed to fund its development. In view of the magnitude of the potential market for computer speech recognition, this could be an extremely important development theoretically, practically and financially.

A new area that is emerging at the Unit is that of research on music. Not only does this offer a useful preliminary test of the spiral processor model, but it also provides an interesting complement to the Unit's extensive interest in speech and language. Hence the parsing processes involved in language production find their counterpart in processes underlying musical improvization, while the similarities and differences between the perception of music and speech have interesting implications for the nature of the underlying perceptual system. Research on music also ties in neatly with work on memory, and research on timing and rhythm in motor performance.

Research on motor skill and action is however, rather less strong than three years ago, with the retirement of Poulton and the departure of McLeod to Oxford and GrudIn to the U.S. computer industry. On the other hand, research on the disruption of movement by brain damage, and its subsequent recovery has flourished in the last three years, and seems likely to continue to be an important component of the Unit's work. Our interest in handwriting also continues and has reached a point at which' it is beginning to spin-off valuable applied results, particularly in the area of forensic science and signature verification. Collaborative work on children's learning of handwriting is a new departure which also seems promising.

An area which has shown signs of increasing in strength since the last progress report is that of visual perception, an area that has been greatly strengthened by the appointment of Watt who will combine a strong theoretical interest in vision with a concern for the applications of vision research to the area of driving and accidents. Work on visual attention continues to be strong while an interest in the relationship between perception and action is shared by a range of scientists who would not describe vision as their primary area of concern.

Application of psychological techniques to the study of photosensitive epilepsy has continued to be profitable, and has produced a very interesting further development. Those patterns that are most likely to induce photosensitive epilepsy are also most likely to induce illusory shimmering and colours in non-epileptic subjects, and to be most strongly associated with reports of eyestrain and headache. This relationship is being extensively explored and may have important implications not only for the understanding of eyestrain and headache, but also for the design of computer visual display units, fluorescent lighting, and even the optimal spacing of lines of print on a page. The Psychophysiology Section has continued to be particularly active in research on sleep. An EEC supported project on the effects of traffic noise on sleep is nearing completion. It involved developing techniques for studying sleep in the home, and yielded the Interesting finding that for most of the subjects studied, the measures of performance proved to be a more sensitive indicator of the deleterious effect of noise on sleep than did physiological EEG measures, although a small subset of subjects does appear to show clear physiological response to outside noise. Traffic noise appears to prevent the sleep of such people reaching its normal depth, suggesting that in the long term their health may potentially be put at risk by the requirement to live under noisy conditions.

Research on shiftworkers also revealed interesting and potentially important effects. Night-shift workers' daytime sleep shows a clear decrement in both amount and quality. Psychological performance also shows steady deterioration over successive days, suggesting that shiftworkers may suffer from progressive sleep deprivation during a week on the night shift.

The section's work on developing portable tests has proved valuable with over 400 of their instruments being bought by establishments wishing to monitor performance. The section's own work on performance monitoring has ranged through the more-traditional areas of detecting the effects of drugs and investigating noise effects to a field study of the influence of human behaviour on the control of domestic heating, a study with obvious implications for energy conservation.

Developments in microprocessor technology have made possible several applications in relation to timing of responses and logging of analog data. This means that various forms of experimentation are now readily portable and reproducible at low cost. Examples Include Norris' tachistoscope program; Bloomfield's clocks for the BBC micro; Wilkins' eye-movement studies; Wing's studies on force and timing in motor control, and Nimmo-Smith's work on handwriting. The accumulation of expertise in applications of microprocessors is yielding increasing returns. It shows promise of meeting the extensive educational and clinical demand for cheap but sophisticated means of testing functions and monitoring progress.

In conclusion, the Unit continues to use a coherent and interconnected set of concepts and techniques to tackle a wide range of applied questions. This appears to be a fruitful strategy, both in yielding results of practical value and in testing, enriching and developing the underlying theories.

# 2.1 STUDIES OF LONG- AND SHORT-TERM MEMORY (Project 32) (Baddeley, Edworthy, Eldridge, Gathercole, Idzikowski, V.Lewis, Logie, Nimmo-Smith)

## 2.1.1 Working memory

Working memory refers to the system that underlies the temporary storage of information that is necessary for performing cognitive tasks such as thinking, reading and learning. A model of working memory that assumes a limited capacity controller, the Central Executive, aided by two active slave systems, the Articulatory Loop for verbal material and the Visuo-spatial Sketchpad for spatial material has continued to prove useful, and a decade of work in the area has been reviewed both relatively briefly (8) and in a forthcoming book (18 U). While a number of studies have been directly aimed at developing the underlying model (22; 20), the essence of the concept of working memory is its concern with the application of memory to other cognitive tasks. Our work has therefore concentrated primarily on studying memory through other cognitive skills and their breakdown, a feature-which makes the assignment of research in this area to a particular project somewhat arbitrary. They are reported together since they do have a common central theoretical core.

## 2.1.2 Working memory and the unattended speech effect

A collaborative research project between Dr. Pierre Salame of the CNRS Strasbourg and Baddeley has shown that immediate memory for visually presented items is impaired by the presentation of irrelevant speech (301). This effect Is not dependent on the meaning of the unattended speech, but does depend on its phonological similarity to the remembered items. The effect is abolished when subvocal rehearsal is prevented by articulatory suppression. This pattern of results has been explained in terms of the articulatory loop component of working memory. Subsequent results have shown that the effect is not sensitive to sound intensity, and does not occur when white noise is used instead of speech, suggesting the existence of some form of filtering process "that prevents non-speech material accessing the articulatory loop (302). We are exploring the characteristics of this filtering mechanism in more detail; in one study we have shown that orchestral music has a small but significant effect, whereas vocal music has a large effect. We plan to extend this research, using the phenomenon to explore the characteristics of the assumed speech filtering mechanism. We also plan to explore the generality of the impairment by looking at other cognitive tasks such as reasoning, arithmetic and comprehension.

#### 2.1.3 Short-term memory for nonverbal sounds

Logie and Edworthy are investigating the overlap between mechanisms involved in the processing and storage of verbal and musical material, within a working memory framework (201 U). Previous experiments by Baddeley & Lewis have shown that rhyme judgments appear to be unaffected by articulatory suppression, suggesting the possible involvement of an auditory image, rather than subvocallsation. Experiments in this project so far suggest that pitch discrimination is disrupted by simultaneous rhyme judgments, but not by articulatory suppression. Melody memory appears to be disrupted by both of these secondary tasks. Neither pitch discrimination, nor melody memory, were affected by a control secondary task involving comparisons of visual symbols. These results suggest that melody memory involves both the articulatory loop and auditory imagery, whereas pitch discrimination involves only auditory imagery. It appears that concepts developed within the context of verbal short-term memory can successfully be applied to the study of auditory, nonverbal information. The working memory framework will continue to be used in further experiments on this project.

## 2.1.4 Short-term memory for visuo-spatial material

The working memory concept has been applied successfully to an understanding of the short term storage and processing of verbal material. It has also been applied to the study of similar functions for short term visuo-spatial material, with some measure of success. However, the 'visuo-spatial sketch pad' of working memory is less clearly understood, and the experimental techniques available lack the tractability of techniques such as articulatory suppression or unattended speech that have been used in the study of the articulatory loop. Logie has investigated the effects of unattended visual material on the use of a visual imagery mnemonic for storage and recall of word lists. This unattended material was found to disrupt visual mnemonic performance, but did not affect verbal rote rehearsal. This suggests two main conclusions: despite instructions to ignore the visually presented material, it is processed at a level sufficient to disrupt visuo-spatial cognitive function; second, unattended visual material appears to provide a more tractable technique than was previously available, for the study of visuo-spatial processing within the framework of a working memory.

## 2.1.5 Visual working memory

A series of experiments by Idzikowski and Baddeley has explored the hypothesis that eye movements may play a crucial role in the setting up or maintainance of visual images (8). An Immediate memory task based on Imagery was shown to be disrupted when subjects were required to track a moving point of light, while no disruption occurred when involuntary eye movements were produced as a result of post-rotational nystagmus. We are currently Investigating whether disruption is caused by the voluntary eye movements themselves, or by the need to control the movement of visual attention.

#### 2.1.6 Working memory and reading

Research on adult fluent reading has confirmed that differences in comprehension ability can be predicted on the basis of a measure of working memory capacity (23), while other studies have attempted to examine the role of the articulatory loop system and phonological coding in reading. They suggest the possible existence of two separate systems, one dependent on subvocal articulatory coding, the other reflecting the separate use of an acoustic image. Evidence suggests that the subvocal articulatory loop system is important for certain reading tasks where a high degree of accuracy is required, and may also play an important role in learning to read (16).

Collaborative work between Logie and Baddeley and Ellis and Miles of U.C.N.W. Bangor suggests that children with specific reading difficulties typically show impaired verbal memory span. They show every sign of using the articulatory loop component of working memory, but the capacity of this system seems to be impaired. Studies of children with developmental reading disabilities in a school specialising in dyslexia so far suggests a surprising degree of uniformity of deficit. A comparison of pattern of errors in these children suggest that earlier claims that they resemble adult deep dyslexics are unfounded, with the pattern resembling more closely that of adult surface dyslexics. Children were often observed to attempt to read by sounding out and remembering each letter of a new word, before attempting to blend the sounds into the target word. What we know of working memory suggests that this is likely to be a highly inefficient strategy, and an alternative approach has "been suggested based on encoding the sound of consonant-vowel pairs or clusters (6; 12). Finally, collaborative work with the Rivermead Rehabilitation Centre Oxford, has looked at the remediation of acquired dyslexia; results suggest that although progress may be slow, relearning is certainly possible (409).

## 2.1.7 Working memory and retrieval from long-term memory

A series of 9 experiments has studied the effect of a demanding secondary task on learning and retrieval from episodic and semantic memory. While concurrent tasks clearly impaired learning capacity, they had little or no effect on the probability of retrieving an item from long-term memory, although latency effects were detected. These results suggest that the process of "searching" long-term memory is relatively automatic and does not require attentional capacity (21).

## 2.1.8 The role of memory in speech perception and production

Gathercole plans a series of studies to investigate the role of the mechanisms involved in speech perception, speech production and reading on the short-term retention of speech material. Two studies exploring the influences of judgments of phonology and speech output preparation on short-term memory are in progress, and some interesting results are emerging. Further work will in particular consider the developmental relationship between short-term memory and other speech-based cognitive skills.

## Z.1.9 The neuropsychology of working memory

Patients with grossly impaired memory span but normal speech and normal long-term memory have presented an important challenge for memory theory in recent years. Baddeley has studied one such patient in collaboration with Dr. Giuseppe Vallar of the University of Milan and they have shown that a working memory interpretation can account for the data by assuming a deficit in the phonological storage component of the articulatory loop (337). Subsequent work has used the occurrence of this very pure deficit to look at the role of that component of working memory in other tasks. One series of experiments has shown that the patient is capable of making phonological judgments accurately, and of comprehending most spoken and written text. She does however encounter problems under certain conditions when the memory load of comprehension is relatively great (338). We are continuing to study the reading comprehension of this patient since it shows certain anomalies that are potentially of considerable theoretical Interest.

A further series of experiments was concerned with the question of whether the articulatory loop system depends on the capacity for overt articulation. A group of anarthric patients without the capacity to articulate were studied by Baddeley in collaboration with Barbara Wilson of the RIvermead Rehabilitation Centre in Oxford. Their memory span performance was virtually normal with clear evidence of phonological coding and subvocal rehearsal, indicating that the articulatory loop system does not require peripheral articulatory feedback in order to operate. There is however clear evidence that memory span is grossly impaired in many aphaslc patients and Gathercole and Baddeley propose to use the techniques developed within working memory to study this.

## 2.1.10 Working memory and dementia

Baddeley and Logie have been invited to participate in a major project on senile dementia of the Alzheimer type by Drs Spinnler and Della Sala of the Department of Neurology at the University of Milan. Current

experiments are exploring the hypothesis that patients suffering from dementia show a particular disruption of the operation of the central executive component of working memory. PhD research at the APU by Morris (236) has shown that mildly demented patients show every evidence of using the articulatory loop system, but are nevertheless impaired in overall memory performance.

Similarly, collaborative work with Milan has shown that the immediate recall of unrelated words by demented patients shows a relatively normal recency effect, coupled with grossly impaired performance on earlier items and grossly impaired verbal and spatial memory span (319 U). We are currently carrying out a series of experiments concentrating on the scheduling and time-sharing role of the central executive component of working memory. Preliminary results suggest that even mildly demented patients show excessive difficulty in scheduling the simultaneous performance of two tasks. We plan to continue research in this area with two aims in view, first to identify sensitive tasks for use in a dementia screening battery, and secondly attempting to use data from patients to extend our understanding of working memory.

# 2.2 STUDIES OF LANGUAGE AND SPEECH (Project 13) (Anderson, Black, Cutler, Johnson-Laird, Norris, Silverman)

## 2.2.1 Prosody

Cutler has investigated the role of prosodic information in recognising words, and has found that although lexical stress patterns are lexically represented (B5), lexical stress does not constrain lexical access (85; 84 U). Instead, stress rhythm appears to play a crucial role in pre-lexical segmentation rather than in word identification (254; 84 U). Higher levels of prosodic structure such as sentence accent and prosodic marking of discourse structure are perceptually valuable.

Prosodic structure carries information about a number of levels of organisation in speech. Silverman is developing a model of how the fundamental frequency (or pitch) is generated, and implementing this model in a computer speech syn the sis-by-rule program. The model views pitch contours in speech as being the result of a hierarchy of factors. At the lowest level, rules remove the "mechanical" sound of computer speech and increase the clarity by representing the influences of vowels (314) and consonants (315) on pitch contours. The middle level is based on current models of intonational structure, and generates a repertoire of intonation contours that is at the same time both richer and phonetically more accurate than existing synthesisers. Collaborative work with Ladd and Scherer in Giessen has shown that intonation contour type and range function independently in communication, and so ought to be separately represented in any model of the production of prosody. Therefore rules in the highest level constrain the overall range of these contours to make them appropriate to a discourse context.

Studies of pre-lexical segmentation by Cutler and Norris have shown that the phonological structure of one's native language can affect the strategies one uses in segmenting continuous speech; for instance, French speakers appear to segment speech into syllable-size units whereas English speakers do not (87).. However, further collaborative studies with Mehler and Segui in Paris cast doubt on the concept of language-specific levels of representation in speech processing: Norris and Cutler have accordingly proposed a new model of pre-lexical segmentation in continuous speech recognition (254), which proposes a language-universal strategy of searching for potential boundaries. The application of this strategy to languages of different phonological

structure has consequences as diverse as the exploitation- of stress rhythm (in English) and apparent syllabification (in French).

Similarly, phonological structure of dialects can affect speech perception strategies within a single language: with D.R. Scott, Cutler found that speakers of British English can acquire and perceptually exploit contrasts in American English, but only if the contrast was not already present, serving a different function, in their native dialect (303).

## 2.2.2 The representation of words in the mental lexicon

It has been argued that because words with complex morphology or multiple meanings or many syntactic constraints are no harder to recognise than simple words, morphological, semantic and syntactic complexity may not be represented in the mental lexicon. Cutler has argued, in contrast, that lexical entries do contain representation of morphological, syntactic and semantic complexity (82; 83), but this does not make words harder to recognise; thus word recognition time is an inappropriate measure of the internal structure of lexical entries (82; 83). The role of morphological structure in word recognition allows an explanation of the general preference for suffixes over prefixes in the languages of the world (86).

## 2.2.3 Comprehension of discourse

Johnson-Laird, Black and Anderson have been engaged since the autumn of 1982 in a project on the factors that affect the comprehension of discourse. These studies are motivated by the theory that comprehension enables readers to construct a mental model of the situation described in the discourse (177). The theory predicts that two main variables should affect the ease of understanding discourse: referential coherence and plausibility. Both these variables have now been shown experimentally to have the predicted effects. A text is referentially coherent if each sentence in it makes reference, either explicitly or implicitly, to at least one entity referred to in another sentence, and hence it is possible to integrate all the sentences into a single mental model. When referential coherence is disrupted, a passage is harder to understand, takes longer to read, and is remembered less well. Conversely, even if the sentences in a text are jumbled up in a random order, referential coherence suffices to make the text considerably easier to understand. Such a text, however, obviously recounts an implausible sequence of events, and plausibility has been shown in further experiments to have a marked Influence on the ease of understanding discourse and of detecting inconsistencies in it. Experiments are in progress to determine the extent to which the two variables of coherence and plausibility interact.

## 2.3 STUDIES OF NORMAL READING AND WRITING (Project 33) (Cotter, Evett, Hull, Morton, Nimmo-Smith, Norris, K.Patterson, Wright)

## 2.3.1 Models of word naming

Norris has developed a detailed model of the word naming process and related it to other measures of word recognition (248; 255 U; 253), while Norris and Brown (253) have shown that although analogy theories and race-models are formally distinct, in practice they are likely to prove empirically indistinguishable. Norris and Nimmo-Smith (255 U) have developed mathematical models of both naming and lexical decision and have shown that the race model can account for many of the differences between the two tasks. Nimmo-Smith and

Morton have developed mathematical models of response times for competing processes, which have" a much wider applicability than solely to word naming.

Two studies of normal reading by Karalyn Patterson address issues which are being concurrently tackled with data from neurological patients.

(a) Modelling the translation of orthography to phonology. The mechanisms by which a reader can assemble a phonological code (pronunciation) for a new orthographic string (e.g. a nonsense word like dake or an unfamiliar name like Tharp) continue to be a matter of compelling theoretical interest and controversy. Original assumptions of a set of a 'nonlexical' rules or mappings between letters and phonemes have been attacked by 'lexical' theories which propose that all such knowledge of mappings can be generated from segmented lexical entries. While there have Indeed been findings in the last five years which the nonlexical theory in its original form cannot explain, there are reasons (some of them neuropsychological) for preferring to retain the notion of two separable routines (one lexical or based on specific words, one nonlexical or based on mapping rules at the sub-word level) for translation between orthography and phonology. Accordingly Patterson, Morton and Nimmo-Smith have developed a modified version of the dual routine model which can deal with the recent controversial findings. A qualitative description of the model is in press (272) and a more detailed and quantitative characterisation of the model is in preparation (243 U). Whilst some of the modelling process has been able to proceed on the basis of available data, we have also been forced to collect substantial data of our own [e.g. Evett et al, (100 U)] because the complexity of our developing model requires a level of specificity not available in most previous research 1n this area.

(b) Right hemisphere reading? As mentioned in the section on acquired dyslexia, some of Patterson's recent work has Involved an evaluation of this controversial topic (232; 266; 267). One aspect of its importance concerns the putative implications of deep dyslexia for models of normal reading. If, as suggested by some theorists, deep dyslexic reading relies on right-hemisphere processes, then we can legitimately apply findings from deep dyslexia to models of normal reading only if we can demonstrate that such right-hemisphere processes also contribute to normal reading skill. We are beginning a collaboration with a team of neuropsychologists in Zurich (Drs. Landis and Regard) who claim to have evidence for such right Hemisphere participation in normal word recognition and reading.

(c) Dual-task studies of word recognition and production. Do the lexical representations underlying word recognition and production within a modality (either speech or print) constitute one sub-system or two? That is, when we recognise-a spoken word, for example, is the hypothetical unit responsible for this event the same as that which must be activated when we want to speak that same word, or are these 'speech' units to be found in a separate subsystem? This issue, although in principle addressable with a neuropsychological approach, has proved somewhat resistant to resolution on the basis of available patient data. Shallice and McLeod have developed a dual-task methodology with normal subjects to address questions of this general type, and have applied - it to the analogous issue on the auditory/speech side (311 U); a collaboration between McLeod and K. Patterson is beginning to ask parallel questions about recognising printed words and output of words in an orthographic code.

2.3.2 Reading and comprehension

A series of studies by Wright and Hull have explored the way readers process conditional instructions (Do A if B), particularly when these instructions involve negatives (e.g. Unless, If not). It has been shown that people have alternative strategies for representing the information in such conditionals (168), but that the mapping between strategy selection and conditional term tends to be stable across rhetorical context (imperative/declarative) (450 U). Specifically, readers represent sentences containing Unless as a negative action and a positive condition, whereas If not is represented as a positive action and negative condition. Many of the dissimilarities between Unless and If not are mirrored by those between Until and While (449 U). This suggests that the negative prefix un elicits a characteristic processing strategy from readers, a strategy different from that used for not.

Drawing inferences is a normal part of most reading activities. Cotter has explored some of the determinants of inferences relating verbs (e.g. cut) to likely instruments (e.g. scissors); we have also examined where these inference processes occur within the ongoing activity of text interpretation (79 U). By noting whether or not reading was slowed by the introduction of an unexpected Item, we were able to show that for some verbs, and Indeed some nouns, readers will instantiate an inferred category at the point of first reading the word (e.g. most readers instantiate the noun nurse as female) (80). The structure of the semantic representation of the word appears to be a strong predictor of the Inferences that readers will draw.

## 2.4 STUDIES OF INFERENTIAL PROCESSING (Project 46) (Johnson-Laird)

Two main sorts of inference are under investigation by Johnson-Laird and his colleagues: formal syllogistic reasoning and informal everyday inferences. Experiments on syllogisms have borne out the prediction that the main factor that affects the difficulty of a deduction is the number of different mental models that have to be constructed in order to imagine all the main ways in which the premises could be true (175). This theory has been fully implemented in a computer model; the next step is to generalize the theory to all inferences involving quantifiers, and to the variety of quantifiers that occur in ordinary language. Everyday inferences are made much more rapidly and much more tentatively than formal inferences, e.g. when you learn that a suspect in a murder trial was somewhere else at the time of the murder, you are likely to infer that he is innocent. When subjects are challenged on such conclusions, they are able to construct alternative models that violate their initial conclusions. A series of experiments (in collaboration with Dr. B. Bara of the University of Milan) are underway to investigate the ease of formulating such alternative conclusions as a function of the strength of the constraints that the premises exert on the initial conclusion. A long-term, aim of this collaboration is to develop a computer model of the process of everyday inference and the role of general knowledge within it.

## 2.5 COGNITIVE MODELLING AND COMPUTER SIMULATION (Project 34) (Barnard, Hinton, Johnson-Laird, K.Lewis, McLeod, R.Patterson, Shallice, Young)

## 2.5.1 Production Systems as a vehicle for cognitive modelling

Following his earlier work on the modelling of errors in subtraction, Young has been collaborating with a number of people at the Open University on a paper based on 10 case studies of production system modelling in order to explore the limits of applicability of the approach (262 U). Two factors appear to determine the feasibility of the modelling enterprise: the quality of the subjects' performance, and the possibility of

performing an adequate task analysis. The account of errors in purely mechanical terms is also being extended by some speculations as to what underlies a child's understanding (and misunderstandings) of simple arithmetical tasks (462 U). An account is offered in terms of the partial assimilation of arithmetical operations by multiple schemata, each of which can contribute to an aspect of the solution. In favourable cases this can lead to the child's "invention" of the solution to a novel kind of problem.

As well as these particular models for particular tasks, there is interest in the notion that the Production System "architecture" itself is responsible for certain features of human cognition. A speculative paper (456) makes the case that properties of the architecture give rise to such invariants of cognition, as that problem solving occurs as heuristic search in a problem space, or that long-term memory search takes place in cycles Of retrieval and re-descript1on.

## 2.5.2 The functional architecture of cognition

Shallice has been engaged in two types of study concerned with this issue. The first in collaboration with McLeod and Lewis is to attempt to develop dual task procedures to answer theoretical questions about functional architecture that have arisen from neuropsychological work. The issue on which there is neuropsychological controversy that they tackled first concerns whether the structures responsible for morpheme-level phonological processing (i.e. logogen or word-form systems), are common to speech input and output. They found that using two tasks that stressed word perception and word production (i.e. detecting a name In a string of auditorily presented words and reading aloud visually presented words both presented at a rapid rate, subjects were able to combine the two tasks making only 10% more errors on average than on the two tasks presented in isolation. They buttressed their conclusion that separate phonological processing structures are involved in speech perception and production by a series of control experiments designed to facilitate theoretical extrapolation from the results of dual task experiments to the nature of the underlying cognitive structure. A paper is being revised for publication (311 U).

In a theoretical paper Shallice (307) assessed Fodor's (1983) theory that the brain is composed of modular input systems and equipotential central systems. He was able to show that modularity as defined by Fodor was too restrictive a concept to give, a plausible characterisation of the architecture of all perceptual systems but also that Fodor's arguments that central cognitive systems are equipotential are probably not valid. Theoretical approaches within APU often seek to furnish accounts of cognitive phenomena on the basis of partitioning the human cognitive system into a variety of processing and memory subsystems. Work on one such model Barnard's "Interacting Cognitive Subsystems", has been developed to provide a conceptual framework for analysing a variety of cognitive tasks. The initial emphasis was to provide accounts of a broad range of short term memory phenomena on the basis of subsystems required to understand and produce language (32). The general purpose architecture, developed primarily to account for laboratory phenomena, is now being explored in relation to its possible applications to the more complex and practical problems of understanding and memory in the context of human-computer dialogues (33 U).

## 2.5.3 Parallel models of memory and perception

Current computer architecture is essentially based on serial processing. It seems likely that the brain approximates more closely to a parallel processing system. In some of the most original theoretical work

carried out at the APU during this period, Hinton developed and simulated a parallel processing model and applied it to memory, perception and motor skills (144; 145; 146; 147; 148). The work was started in the rather more computer-rich departments of Sussex and San Diego, and is now bearing fruit in the computer science department of Carnegie-Mellon University, but was carried on successfully at the APU by using, with great ingenuity, the very spartan technical resources of an Apple Microcomputer. This line of research holds great promise, both in implications for understanding human cognition, and in its potential significance for computer design.

## 2.5.4 Simulation of musical Improvisation

Johnson-Laird has written a suite of programs that simulate the process of musical improvisation. The basic theoretical claim on which the programs rest is that the process of improvisation, since it occurs rapidly and fluently, must minimize the amount of musical structure that has to be constructed in order to produce each note. Hence, the required computational power may be as weak as that of a finite state device. Johnson-Laird has devised (a) a program that improvises a bass line to a given chord sequence, and (b) a program that Improvises a melody to a given chord sequence. Both programs utilize merely this degree of power yet achieve considerable verisimilitude. In the case of the generation of chord sequences, however, there is no such real-time constraint, and in fact it appears that the power of at least a push-down automaton is required to carry out this task. A third program has been devised that creates acceptable tonal chord sequences, and it depends on this greater degree of computational power. These musical programs have been interfaced with the Unit's specially built computer for generating complex sounds; and Roy Patterson and his colleagues have developed the software for producing musical notes. This collaboration will continue, and the project aims to lead both to theoretical insights and to practical applications in the domain of musical technology.

## 2.6 NEUROPSYCHOLOGY OF COGNITIVE BREAKDOWN (Project 1) (Baddeley, Duncan, Gathercole, Harris, Hatfield, Kay, McCarthy, Marcel, Morton, K.Patterson, Shallice, Sunderland, Wilkins) 2.6.1 Cortical blindness

Marcel and Wilkins are continuing work on cortical blindness. Patients with lesions to cortical visual projections on one side, but not to subcortical projections, have no phenomenal vision in one half of the visual field. However some of these patients show accurate pointing to and accurate adjustments of wrist and fingers to shape, size and orientation preparatory to grasping objects in the blind field of which they are unaware. In addition some patients are sensitive to the structural descriptions of strokes which constitute letters. Further, in the blind field conscious vision of after-images and of illusory contours can be produced if facilitated by related stimulation in the sighted field. Such findings not only elucidate the nature of cortical blindness, but throw light on the nature of visual consciousness (228 U).

#### 2.6.2 Action and Motor Control

Although almost completely ignored by the research literature, it is a common-rehabilitative technique (for eliciting and improving motor control for both peripheral and central problems) to embed the required behaviour in a higher-level task. In conjunction with the Rehabilitation Centre at Addenbrooke's Hospital Marcel has been exploring the validity of the phenomenon and in whom it occurs. We have established in a sample of neurological patients with various motor deficits that if a piece of motor behaviour is part of an action, then it

is easier to retrieve and is performed more efficaciously than when it is the nominal focus of the task. This appears not to be entirely an attentional phenomenon. The importance of this is twofold. Therapeutically, one may validate and delineate a technique for eliciting and improving motor control. Theoretically, one may throw light on the way in which motor behaviour is influenced by the nature of the intention.

## 2.6.3 Acquired dyslexia

With realisation of the multiple sub-processes involved in a complex cognitive skill like reading, it becomes obvious that neurological damage will yield a wide variety of patterns of breakdown rather than just a few discrete syndromes. This state of affairs underlines the value of the single case-study approach, so extensively adopted in research at the APU and gaining increasing acceptance in neuropsychological centres elsewhere. Despite the fact that each single case is unique, basic patterns ('syndromes' or 'symptom complexes') provide a framework within which the variability can be described. Review chapters summarising the most prominent patterns of acquired dyslexia (268) and the major neuro-psychological tests and techniques for assessing acquired reading disorders (74) will appear shortly in a major handbook on aphasia.

## 2.6.4 Non-phonological reading

Previously, much of the Unit's research in this area concentrated on deep and phonological dyslexia, involving disorders of the phonological sub-processes which enable normal readers to pronounce unfamiliar printed words or names. The only recent work on deep dyslexia has been K. Patterson's critical evaluation of the hypothesis that deep dyslexia reflects reading skills localised in the right hemisphere of right-handed (left-hemisphere dominant) individuals (232; 266; 267). Phonological dyslexia is currently being studied by Marcel and Patterson in an attempt to specify why these patients, whose reading of familiar words is nearly normal, fail to pronounce even very simple new words or nonwords (like dake). At least three procedures are necessary to read aloud such a letter string: segmentation of Its orthography, assignment of phonology to the individual segments, and assembly of the phonological segments into a spoken syllable. Alternative theories about the nature of these procedures in normal reading make differing predictions regarding the locus of the deficit in phonological dyslexic patients, and also about the way in which patients with other patterns of reading impairment should perform on tests of these component procedures (182). New more sophisticated tests, devised by Marcel and Patterson, have now been given to five phonological dyslexic patients and are currently being given to other patients.

## 2.6.5 Phonological reading

Recently a primary focus of our work on applied dyslexia has been patients whose reading involves an abnormal reliance on the phonological processes which are absent or impaired in deep/phonological dyslexia. Although at an early stage this pattern was considered a single syndrome (called surface dyslexia), it is now clear that phonological reading can take a variety of forms. Indeed, Shallice and McCarthy (310) argue that the form of reading impairment shown by the original patients labelled surface dyslexic is best conceived not as reliance on a phonological routine but rather on a compensatory strategy related to letter-by-letter reading. Two issues of major theoretical interest have guided out work on phonological reading. The first concerns its informative value for theories of the phonological routine in normal reading, requires a relatively pure disorder as in the patient studied by Shallice, Warrington and McCarthy (313). This patient was grossly impaired in

terms of reading based on recognition of whole familiar written words but had a largely preserved phonological routine for reading as demonstrated by (a) normal reading speed; (b) a large effect on probability of oral reading success of the word's regularity of grapheme-phoneme correspondences; (c) a predominance of errors of a pure regularisation type (e.g. pint: "pint", rhyming with "mint"); and (d) equivalent success on nonsense words and regular monosyllabic words. The 'multiple levels' model of phonological reading suggested by Shallice et al (313) has been further developed by Shallice and McCarthy (310). The model assumes that information about different sizes of orthographic unit - grapheme, demisyllable, syllable and morpheme - can be passed in parallel from orthographic to phonological processing systems in spelling-to-sound translation. Impaired phonological route reading corresponds to a loss of some - normally the higher - of these levels of correspondence. Analogies with scene recognition programs were developed to support the idea that the model was computationally practicable.

The second issue concerns the status of reading comprehension in patients whose oral reading relies on phonological processes. Original interpretations of surface dyslexia concluded that both pronunciation and comprehension were dominated by segmental phonological assignment (so that, for example, the printed word bear would not only be pronounced as "beer" but also understood as referring to an alcoholic drink rather than a large mammal). Now, however, and entirely consistent with our process models of reading, patients have been identified who read (aloud) phonologically but comprehend orthographically (saying "beer" to bear but defining the written word correctly) (230; 183). Phonological reading associated with deficits at output rather than input does predictably co-occur with output problems in other language tasks as well, particularly spontaneous speech and naming. Marcel's study (230) also focussed on the variability of the patient's responses and concluded that observed behaviour patterns, rather than reflecting an information-processing deficit, may reflect strategies or biases in response to a deficit. These biases appear to be affected by attention and task pragmatics.

A book on the topic of phonological reading, edited by K. Patterson, Marshall and Coltheart (271) will be published in the spring of 1985 and includes four chapters written by APU members (230; 272; 183; 310).

## 2.6.6 Letter-by-letter reading

In earlier papers, Warrington and Shall1ce (1980) and Patterson and Kay (270) have presented evidence that patients suffering from the classical syndrome known as letter-by-letter reading show no comprehension or ability to perform lexical decision on briefly presented words. Reading is dependent on a laborious letter-by-letter process. In collaboration with Saffran, Shallice has undertaken a lengthy series of experiments on an apparently very typical letter-by-letter reader who performs well above chance on lexical decision tasks and semantic judgements even on words he can neither read nor identify. He also appears insensitive to the appropriateness of affixes when performing lexical decision. A number of possible explanations of why he differs from letter-by-letter readers are developed. A short account of the work 1s presented (309), and a core extensive publication is at present being revised (312 U).

## 2.6.7 Reading, naming and semantics

It is a moot issue to what extent the semantics accessed by written words and by perceived objects are common or separate. Marcel, in collaboration with Margolin of the Good Samaritan Hospital, Portland, Oregon,

has studied a woman who suffered anomia and alexia following a head trauma. As her language improved, she produced descriptive circumlocutions when both reading and naming. These responses were strikingly similar for a given word, whether in reading or naming a picture. This observation together with experimental interactions between semantic, phonological pictorial and orthographic information suggest that a common set of semantic representations are accessed and used in recognition and naming of objects and in recognition and reading of words. (229 U).

#### 2.6.8 Acquired dysgraphia

Disorders of writing and spelling are rapidly catching up with reading as a major focus of neuropsychological research. It is particularly Intriguing to identify those aspects of spelling procedures which can be modelled with processes or routines borrowed from models of reading as opposed to those aspects of reading and spelling which require differing theoretical accounts (140; 264). In terms of patterns of acquired dysgraphia, as with reading, Patterson and Hatfield now have considerable evidence about spelling performance both where the patient has severely impaired or abolished phonological skills (141; 274) and where, due to impairments in the word-specific lexical procedures for spelling, the patient depends primarily upon phonological skills (140).

## 2.6.9 Aphasia

The period covered by this report saw the termination of Patterson and Morton's DHSS-supported research to evaluate techniques of speech therapy for word-finding difficulty in picture naming tasks. Summarised briefly, the study demonstrated that (a) single applications of techniques based on the sound of the sought-for word provide major immediate assistance to the patient but no lasting benefit (Patterson, Purell and Morton, 1983); (b) single applications of techniques based on the meaning or referential properties of the word provide facilitation of word-finding that may last hours or even days (154); intensive treatment sessions (every day for one or two weeks) provide significant cumulative benefit whether the techniques used are based on word sound or meaning; but naming performance begins to decline., as soon as the therapy period terminates (155 U). The very extensive data collected also enabled us to address other questions of interest, such as consistency of naming performance over sessions (153). Some of the therapeutic implications of this study are addressed in these published papers, and also in our final report to the DHSS (273). Also, we are exploring implications for design of therapy procedures derived from the single-case methodology which has been so theoretically productive (269 U).

Work is beginning on the aphasic disorder (or set of disorders) known as agrammatism, in which language production and/or comprehension can be roughly characterised as impaired at the level of grammar or syntax. One case study of a pattern rarely reported in the literature has revealed a patient agrammatic in spontaneous speech but not in other tasks requiring verbal output such as repetition or oral reading of sentences (265 U). Other work just beginning (K. Patterson in collaboration with L. Tyler) will use Dr. Tyler's sophisticated model of word recognition in speech comprehension to characterise various aspects of agrammatic disorders.

## 2.6.10 working memory and aphasia

A new line of enquiry by Gathercole and Baddeley concerns the memory characteristics of neuropsychological patients with aphasia. Research using normal populations of subjects has established a strong articulatory component In short-term memory, as demonstrated in particular by word length and articulatory suppression

effects. Recent work by Baddeley has shown that dysarthric patients - people who have motor problems associated with articulation - still display evidence of articulatory coding in memory. The present study seeks to investigate the contribution of speech coding to the short-term memory of some aphasic patients who have speech output problems in the absence of dysarthria. It is hoped that this investigation will provide further insight into the nature of articulatory representations in memory. Close collaborative contacts with the Speech Therapy Department at Addenbrooke's Hospital in Cambridge have been established, and memory testing of aphasic patients is in progress.

A further project planned by Gathercole and Baddeley concerns memory in children with language disorders. The children in whom we are particularly interested spontaneously produce utterances of limited length only, and one hypothesis which will be investigated is that an Impaired auditory memory system is associated with this type of disorder. More generally, the aim of this investigation is to explore the reciprocal relationship between short-term memory and the development of language. At present, we are involved in establishing a suitable group of children for testing.

## 2.6.11 Memory span and epilepsy

Wilkins, in collaboration with colleagues at the Instituut voor Epilepsiebestrijding, Heemstede, The Netherlands, has adapted verbal and non-verbal tests of short-term memory for clinical use with epileptic patients. The tests take the form of television games that are entertaining when played for lengthy periods. They have examined patients whose seizures are reasonably well controlled but whose medication is insufficient to eliminate occasional epileptiform EEG abnormalities. The tests have revealed selective. Impairments of verbal or non-verbal memory span associated respectively with focal EEG abnormalities of the left and right temporal regions (1; 2).

## 2.6.12 Amnesia

Recent research in this area by Baddeley concerned the question of whether amnesic patients show impaired episodic memory but normal semantic memory (10), a question that led on to the exploration of autobiographical memory in amnesia. Collaborative work with Barbara Wilson of the Rivermead Rehabilitation Centre Oxford has led to the observation that marked differences exist in the extent to which otherwise apparently equivalent patients have access to memory of. their earlier lives. This led to an initial triple categorisation of patients as having normal, clouded or confabulatory autobiographical memory (27). Patients who confabulated all suffered from frontal amnesia; a further study .comparing frontal amnesia with other amnesic deficits 1s in.preparation. We are also in the process of developing an improved assessment of autobiographical memory (Jointly with Wilson, Rivermead, Oxford and Kopelman, Institute of Psychiatry, London).

## 2.6.13 Studies of semantic memory

The first detailed quantitative case studies of a selective impairment of certain semantic classes of material has been undertaken by Warrington and Shallice (339). Their paper concerned the visual identification and auditory comprehension deficits of four, patients who had made a partial recovery from Herpes Simplex encephalitis. In all four patients a very large difference between the ability to identify Inanimate objects and the Inability to identify living things and foods was demonstrated. In two patients it was possible to compare processing of

auditory verbal and visual non-verbal stimuli; a similar pattern of dissociations was seen in both modalities. In one patient comprehension of abstract words was far superior to that of concrete words. The findings are interpreted in terms of the category specific organisation of semantic systems.

In a theoretical review Shallice (309) has analysed disorders within the semantic system on two dimensions in addition to the possible category specificity of the impairment - according to the modality of presentation (or of connections within the semantic system) and on whether the disorders are of "access" or "degradation", developing a dichotomy originally put forward by Warrington and Shall1ce (1979).

## 2.6.14 Amnesia and everyday memory

Our previous progress report referred to an ongoing study by Sunderland, Harris and Baddeley concerned with the measurement of everyday memory problems encountered by patients suffering from closed head injury. That study was completed, (320; 321) and an equivalent study on the memory problems of the elderly has subsequently been run. The main focus of both studies was on the relationship between laboratory-based objective memory tests and memory problems encountered in everyday life. We explored the use of Interviews both with the patient and with relatives, together with the use of check lists and diaries. The results of both studies indicated that neither standard tests nor questionnaires are entirely satisfactory. Some standard tests reveal clear deficits that appear to be unrelated to everyday problems. On the other hand, interviews with the patient proved to be of limited value; the patients often appear to forget their lapses of memory (321; 24). This has led to a collaborative project with Barbara Wilson of the Rivermead Rehabilitation Centre concerned with evaluating a behavioural memory test. This comprises a number of objectively scoreable subtests, each of which attempts to simulate one area of everyday life that patients report gives rise to memory problems. Performance on the test 1s currently being validated against extensive observations by therapists, and will be correlated with objective memory tests, and subjective estimates by the patient and a relative. Preliminary results are encouraging (410), the test is already arousing considerable interest and being used in joint studies on dementia (with Dr. Wegener of the Merck Drug Company in Darmstadt), on depression and ageing (with Dr. Poon In Boston) and on memory in stroke patients (with Dr. Lincoln in Nottingham).

The head injury and memory project stimulated an interest in treatment. A preliminary survey indicated considerable interest but relatively little activity in treatment of memory problems (136). This in turn led to the organisation of a workshop, jointly with a number of clinicians interested in this topic. The publication of a book on the management of memory problems followed, with chapters contributed by the APU on the relation between theory and therapy (11), and on methods of improving memory (134). A second conference was organised some two years later, and it was gratifying to note the extent to which this complex but important area is developing. While it would be irresponsible to pretend that dramatic improvements in memory problems can be achieved, there is good evidence that given appropriate techniques some amelioration is possible.

## 2.6.15 Frontal Lobe Disorders

Five empirical studies of frontal lobe function have been carried out: -

(a) A study of planning abilities was carried out by Shallice and McCarthy using a test devised so as to be related to the Tower-of-Hanoi puzzle, but to be of graded difficulty. In an unselected series of localised lesion patients it was found that the group of patients with left anterior lesions were significantly impaired when

compared with either a left posterior lesion group or. a right anterior lesion group. In an experiment on normal subjects it was found that articulatory suppression had no effect on the ability to solve the task and an "Inner speech" deficit did not therefore seem a plausible explanation of the left anterior deficit. A short account of the research has been published (306); a more extensive version is being prepared for publication.

(b) A directed forgetting task was developed by Shallice and McCarthy in which a form of span involving subsequent Instruction to forget some of the presented material Is contrasted with normal span. Patients with anterior lesions were selectively impaired on the directed forgetting condition. As no interaction was observed with hemisphere the deficit would appear to arise from a general programming or attentional problem for a novel and demanding task rather than any difficulty with, say, inner speech. It is at present being considered whether, further investigations need to be carried out on this point before the work is written up for publication.

(c) Previous work at the National Hospital with Professor Warrington and Ms Oldfield has attempted to develop a battery of tests sensitive to frontal lobe lesions. For a number of methodological reasons this work has not been successful. Shallice and Lewis together with Warrington have been engaged in an attempt to improve their previous technique of using an unselected series of patients with localised lesions by screening such patients extensively for inclusion in a further series. Only patients in whom basic perceptual and cognitive skills were intact and IQ measures are relatively unimpaired are being included; the patients are then being assessed on a group of ten tests thought from the literature to be sensitive to frontal lobe pathology. The series is at present about half complete and is expected to take another year.

(d) Shallice and McCarthy have extended a study originally carried out in Montreal by Wilkins and have replicated the original findings with a very different group of neurological patients at the National Hospital, Queens Square, London. In both studies, patients with frontal lesions were less able to perform a simple routine counting task, but only when it was given at slow presentation rates, a condition that required patients actively to concentrate their attention (389 U).

(e) Shallice, together with Beauvols and Oerouesne of INSERM 84, Hopital Salpetriere has been engaged in the analysis of the memory disorder of a patient showing amnesia with confabulation following operation for an anterior communicating artery aneurysm. The investigation involved an extensive series of tests of memory, attention and cognition and the provisional findings are that a frontal memory disorder exists which is not secondary to a primary amnesia, concentration difficulties or the more general cognitive problems associated with frontal lobe pathology. A preliminary account has been submitted to the International Neuropsychology Society European meeting for 1985 but investigations are still continuing.

Shallice, together with D.A. Norman of the University of California has developed a theory of the higher level cognitive function associated with the frontal lobes which is the first to be put forward within an information-processing framework. They have been able to interpret a number of impairments obtained with frontal lobe lesions within the theory (306). It is also possible to account for a number of phenomena in the psychology of attention within their approach (245). Baddeley has utilized the Shallice and Norman model within the central executive component of his working memory framework (8 U).

Duncan is investigating the relationship between the "frontal lobe syndrome" and the aspect of individual differences in the normal population measured by so-called "Intelligence" tests. People with low scores on such tests seem to have particular difficulties when beginning new tasks, yet to perform reasonably once the correct structure of operations has been achieved. In particular, they can show initially a pattern of behaviour quite reminiscent of one aspect of the frontal lobe syndrome: A failure to correlate performance with goals and/or instructions, though these have been understood verbally. It is proposed that this type of correlation Is vital when new tasks are begun, but then rapidly loses importance, perhaps even after only one or two successes. Work is in progress to test this Idea both in the normal population and In frontal lobe patients.

## 2.7 COGNITIVE ASPECTS OF DYSFUNCTION AND TREATMENT IN PATIENTS WITH PSYCHIATRIC AND OTHER EMOTIONAL PROBLEMS (Project 44) (Broadbent, Levey, A.McLeod, Marcel, Nulty, Sharrock, Trezlse, Watts, Williams)

This project, which has developed since 1981, has applied techniques and theories derived from experimental cognitive psychology to emotional disorders. Though clinicians have become increasingly concerned with cognitive aspects of emotional disorders, the experimental approach taken in this project is relatively innovative. The project has three general alms (a) to describe and develop a theoretical account of cognitive processing in emotional disorders (b) to evaluate cognitive change in established behavioural therapies and, where appropriate, to develop therapeutic applications of processing strategies and (c) to contribute to the general development of cognitive theory an awareness of how cognition and affect interact. The main focus so far has been on the first of these; the other two will come to greater prominence as the project develops. The subjects studied so far have been partly clinical groups (depressed psychiatric patients and overdose patients) and partly volunteers recruited by advertisement (spider phobics and 'worriers').

## 2.7.1 Cognitive processing in spider phobia

Spider phobics have been a major focus of work in the early stages of the project, because the discrete nature of the emotional stimulus makes the study of cognitive processing relatively straightforward. A preliminary step was to develop a questionnaire measure of spiders which both provides a rapid check on the overall severity of the phobia and also measures specific dimensions derived from factor analysis (vigilance, preoccupation and avoidance) likely to be relevant to cognitive processing (371). A Stroop test has been developed requiring the colour naming of spider words, for which spider phobics show very long response latencies (375 U). This has shown promise as an outcome measure in evaluating the effects of desensitization. Because the size of the effect is larger than in any other emotional Stroop so far reported it lends itself to studies of the processes involved, and work on this is in hand.

Another series of studies by Watts has used dead spiders as the stimuli and demonstrated a tendency for phobics to show 'shallow' processing of spiders, reflected in poor memory for them. It is planned to study the extent to which this Interferes with the clinical effectiveness of exposure-based treatment of phobics, and this will probably be studied in agoraphobics. Memory for spider words has been studied by Watts and Trezise and it has been found that spider phobics show reduced free recall for spider words, though recognition memory remains good (376 U). This is contrary to the well established finding of enhanced recall of negative words in depressed mood states, and raises issues about which disorders show enhanced and which reduced recall of

salient words. A parallel study of sub-clinical anorexics is in progress, together with further work on spider phobics aimed at disentangling possible explanations of the effect. Other work has used self-report measures of cognitive representations and shown that, in phobics, spider constructs are unusually highly correlated (372) and spider imagery is poorly elaborated (374 U).

## 2.7.2 Concentration and memory in depression

Another line of work by Watts, Trezise and McLeod has Investigated concentration and memory problems In relatively severely depressed patients. An initial study (373) used a structured interview to explore the phenomenology of concentration problems. It also used a variety of objective tests to establish a dimension of concentration problems that spanned data domains, and yielded a representative index that could be used in future work. Current work is examining the hypothesis, derived from the preliminary study, that depressed patients have two kinds of concentration problem, one relating to processing input, and the other experienced in interactive tasks. Processing strategies designed to help patients with the first of these are currently being evaluated. Work is also in progress on the locus of memory problems in depression.

2.7.3 The assessment of specific psychological factors affecting recovery from self-poisoning

Parasuicide is a large and increasing problem, the number of incidents having increased over the past twenty years from 30,000 to 130,000 pa in the UK. Yet to date mental health workers have not found any physical or psychological treatments which reliably reduce the risk of repetition (402). This project has been set up to examine individual differences in the process of recovery from the emotional stress surrounding the attempt. Specifically, Williams and Broadbent are studying the interrelationship between mood, hopelessness and biases in attention and mood related autobiographical memory. Two independent forms of mood-related biases in processing have been identified. The first related to increased sensitivity to constructs related to negative themes (407 U) the second related to retarded retrievability of positive personal memories (406 U).

## 2.7.4 The effect of depressed mood on lexical decision and subsequent recognition ot emotional and neutral material

In this project, Williams examines' predictions from associative network theory of emotion by studying the effect of level of depression on the extent to which negative words are responded to more quickly in a lexical decision paradigm. Two further aspects are being studied: (a) the effects of priming on lexical decision and (b) the extent to which target words from the lexical decision task are accurately recognised later (using a false recognition paradigm).

## 2.7.5 Worrying and working memory

Williams, Watts and Levey are studying the effect of articulatory suppression on latency to recruit or dismiss "worrying" and "neutral" thoughts in a clinical subpanel of "worriers". This study is also indicating a distinction between several dimensions of worrying; we plan to examine the correlations between these dimensions and depression, general trait anxiety, frequency of automatic negative thoughts, and dysfunctional cognitive style.

## 2.7.6 Conscious and nonconscious processes in dynamic and cognitive psychology

In cognitive psychology there has recently been a resurgence of interest in both consciousness and nonconscious processes. Dynamically oriented theorists and researchers have looked to this work for its potential relevance to psychoanalytic issues. Marcel has examined this attempted rapprochement and has

argued that the work in cognitive psychology is irrelevant to psychodynamic concerns. However It is pointed out that the hermeneutic focus of much psychoanalytic work is an important aspect of cognition omitted by the natural science approach of cognitive psychology.

The treatment of meaning by cognitive psychology and its significance for cognition can be helped by the work of social anthropologists (226).

## 2.7.7 Clinical psychophysiology

The study of cognitive functions tends by its nature to pay less attention to other functional activities Including motivational and emotional components of behaviour. This imbalance is redressed in the program of the Unit, through an area of research broadly classified as psychophysiological, which studies autonomic functions in relation to cognitive activity. This area includes studies by Levey in collaboration with Dr. Martin of the Institute of Psychiatry of classical conditioning of simple reflex behaviours which are affected by individual differences in arousal (186; 187; 188) or of more complex behaviours directly involving emotional attitudes (190). The classical conditioning paradigm can be regarded as a very simple form of Information processing in which the significance of novel stimuli 1s modified in the context of phylogenetically primitive emotional reactions. For this reason it offers an ideal focus for studying the interaction of cognitive and emotional components in laboratory based behaviours (192 U) but also offers the prospect of a better understanding of clinically relevant (maladaptive) behaviours in real life (189; 191).

A major focus of this project is the application of the concepts and methods of classical conditioning and the study of psychophysiological disorders. Studies of heart rate, pulse volume, respiration, gastric activity, and electrodermal responding have shown that some individuals fail to extinguish responses conditioned normally in these organ systems (193). These individuals are characterised by low arousal levels and by inefficient cognitive processing of environmental stimuli (194). They are consequently at risk for the development of psychosomatic disorders. The practical implication of these findings is that the methods of deconditioning and cognitive restructuring which has been successfully applied to other learned maladaptive behaviours may also be applicable in modified form with psychosomatic illness.

# 3. COGNITIVE ERGONOMICS/APPLIED COGNITIVE PSYCHOLOGY

## 3.1 HUMAN ERROR AND SAFETY (Project 29) (Baddeley, Brown, Idzikowski, V.Lewis, Logie, McKenna, Sunderland)

There are many real life settings in which simple errors can be both costly and dangerous. These include driving, flying and industrial settings. Several approaches can be taken to minimising such errors, including personnel selection, task change, training, and public education. McKenna (212) has published a general review of these for the case of driving accidents, and another (213) dealing in detail with the concept of accident proneness, i.e. the idea that some people are more likely to have accidents than others. Brown is currently preparing an invited paper (64) which reviews the prospects for improving road safety, given our

existing knowledge of accident causation, and which examines various reasons for the non-implementation of known road accident countermeasures.

In some situations the ability to perform adequately may in part be determined by a person's response to stress. For example, the effects of driving fatigue have been attributed to a generalised response to prolonged stress (59). Emotional reactions may also constitute distraction from the task at hand. Preliminary research by McKenna shows that presentation of emotional words can indeed interfere with performance of a central task (colour-naming). Interestingly, pilot trainees in the RAF are more susceptible to such interference than are members of the population at large (222 U). Continuing work will show whether this test can make a useful contribution to pilot selection.

An important idea in the literature is that accident countermeasures in general cannot work. "Risk Homeostasis Theory" proposes that, when a situation is perceived to become safer (e.g. through introduction of seat belts, improved crashworthiness of vehicles, and so on), people adjust the demands they put upon themselves (e.g. they drive faster) to bring accident rate back to its original level. This view, implying that safety research in general is a waste of time, has been criticised on grounds of both its psychological plausibility and its empirical support (212; 218). There is, however, some evidence that people offset at least part of the potential gain in safety from accident countermeasures by adjusting their behaviour to maintain stable target levels of risk. If this is generally true, it follows that research should concentrate on identifying those proposed countermeasures in which the ratios of actual to potential gains in safety are high, and the measures therefore most cost-effective.

Validating safety improvements is a major problem in this field, because most formal accident-reporting systems either record only injury accidents, or serve merely to apportion blame. Neither of these reporting methods provides reliable criterion measures of unsafe human behaviour. Yet accident data often are the only credible means of identifying safety problems, or validating accident countermeasures. Attention is therefore being given to the improvement of behavioural data obtainable from accident records and to the identification of accident surrogates; such as road traffic 'conflicts', or similar near-accident 'incidents'.

#### 3.1.1 Stress and performance

While there are many reports that fear impairs cognitive performance, there is little objective data. Idzikowski and Baddeley have attempted to collect evidence on this issue by testing subjects immediately before they subject themselves to some physical danger such as that involved in parachuting (159), or diving (19), or to a potential social threat such as that often suffered by an inexperienced public speaker (158). While performance decrements were obtained in all three situations the magnitude of the decrements was surprisingly small. While this may be a result of testing the subject some time before the point of maximum anxiety, the ethical and logistic problems of experimentally achieving higher levels of fear are considerable (159), suggesting that subsequent studies in this area might more profitably concentrate on patient populations such as phobics, in whom high levels of anxiety may be encountered during the process of desensitization.

Over the past few years Lewis, Logie and Baddeley have continued to collaborate with the AMTE Physiological Laboratory in studies of deep diving. Since each dive may last a matter of weeks and is extremely costly this has involved the development of designs for drawing valid conclusions from, the performance of individuals or

pairs of subjects. We have been successful in detecting the effects of pressure and breathing mixture on a range of aspects of performance (198; 199). Having produced a suitable test battery, our current role is largely to monitor its use by AMTEPL. Should new developments occur, for example open-sea testing or diver screening, we would expect to increase our involvement in this area once again.

In the meantime, the Unit's general expertise in psychological measurement continues to be employed in a wide range of studies. Sunderland is currently collaborating with the staff of an Oxford hospice to study the cognitive side effects of morphine, while Baddeley is involved in the measurement aspects of a clinical trial comparing conventional physiotherapy treatment for back pain with that offered by chiropractors, currently being run from the Epidemiology and Medical Care Unit.

# 3.2 PERCEPTION AND DECISION IN TRANSPORT SYSTEMS (Project 40) (Brown, Duncan, McKenna, Watt)

There are three strands to research on this project, distinguished largely by their potential for designing and implementing countermeasures against accident-provoking errors of perception and decision, but all following from Brown's continued interest in the safety of transport systems.

(a) Individual differences. The first approach formed part of the five-year progamme of research into individual differences in accident liability which commenced in 1978. This programme now has longer-term support from tenured members of staff (Brown, Duncan, Watt) and certain aspects of their work will fall, more appropriately, under Project No. 29: Human Error and Safety.

Under Project No. 40, Brown, McKenna and Duncan examined the claim, arising from work in other laboratories, that a person's accident record can be predicted from laboratory tests of certain cognitive abilities. Research has concentrated on two abilities in particular, focussing and switching of attention, and search for camouflaged targets (related to the "cognitive style" of field-dependence/independence). Extensive projects have been undertaken in collaboration with London Transport, the RAF, and the Transport and Road Research Laboratory. Results, on the whole, have been negative. No laboratory test used was found to be a good predictor of an individual's accident record. There are several good reasons for this. Most importantly, many different cognitive systems must contribute to a crude measure such as accident rate, or success in a training course. No single test is thus likely to predict overall performance (223 U).

A potentially better approach is to study the various components of complex tasks, such as driving or flying, rather than measuring overall 'success'. Work of this sort is continuing in collaboration with the RAF, whose interest in personnel selection dictates their continuing concern with individual differences. A second approach is neuropsychological. In collaboration with the RIvermead Rehabilitation Centre, Oxford, a three-year programme of research is planned to examine the driving abilities of stroke and head injury patients who wish to return to driving. Detailed information, both on different aspects of driving skill and on a wide range of cognitive functions, may help to understand how a complex task is constructed from its component parts-and to produce tests helpful in the screening of brain-damaged patients.

[N.B. The Rivermead proposal may suffer from financial cuts. It is currently under consideration for funding by DHSS and DT. Whilst DHSS seems happy to provide 50% support, DT are to date unsure that their resources can be extended to cover the remaining 50%.]

(b) Perception of hazard. Another approach forms part of the second strand of Project No. 40. This explores the effect of specific task or environmental demands on perception and decision. Since 1983, Brown has chaired a new working party set up jointly by the Medical Commission on Accident Prevention and the Institution of Highways and Transportation. A retrospective study of accident data provided by the Transport and Road Research Laboratory and by various regional highway authorities has established that perceptual errors contribute to about half of all reported road accidents involving 'unimpaired drivers' during daylight. The extent to which highway design characteristics contribute to this substantial misperception of hazard by road users is currently being examined. Collaborative prospective research with regional highway authorities is scheduled to examine the causal relationships between specific highway features and 'misperception' accidents. It is hoped that this study will include a methodological examination of the 'traffic conflicts' technique for assessing accident risk in the road traffic system.

[N.B. This prospective study will probably be submitted to DT for funding and financial cuts may prevent its implementation in the foreseeable future].

Watt plans two contributions to this strand of the project. The first examines road markings, which provide a cheap means of improving the streaming of traffic, particularly at busy or blind junctions. They also have several perceptual possibilities, such as providing cues to road position, to road contours, perhaps also to hazard. In addition, suitably designed markings will provide a frame of reference within which the actions of other road users should become more interpretable. Against these benefits there may well be costs, such as confusion and, more seriously, the problems of visibility of road markings under less than ideal conditions. Watt's second contribution examines vehicle markings. Safe driving requires not only good vehicle control, but also accurate and reliable perception of the behaviour of other vehicles. Some shapes of vehicle and forms of vehicle marking provide more information in this respect than do others (consider the limiting cases of nearly spherical or rod-like shapes, where all changes in road position with respect to an observer lead to only translations and dilations of the image, and no self-occlusions or more complex shape distortions are produced). In these areas a mixture of "reduced" psychological testing and "real-life" observation is proposed to form both design guidelines and a theoretical base.

(c) Self-induced risk exposure. The third strand in this project follows from the fact that the demands imposed on users of transport systems is largely self-imposed. Errors and accidents thus result when task demand is inappropriately matched to the individual's abilities and kills. Such mismatches may result from perception and decision failures associated with intelligence, personality or temperament. Age and experience have already been shown to affect hazard perception on the road (65; 73) and Brown plans to examine the extent to which this effect results from the differential acquisition of vehicle control skills and 'roadcraft' during drivers' training and Initial experience.

The quarter-million injury accidents occurring on British roads each year indicate the social importance of this work. It is encouraging that the Transport and Road Research Laboratory has recently approached the Unit to foster increased collaboration in the laboratory's programme of research on road user behaviour.. Work on this project, especially that involving hazard perception, is therefore likely to increase in the near future, if outside funding becomes available.

Cost-effectiveness of such research is lively to be high. This is partly because research findings have a clear application. Certainly there is good evidence already for the high payoff from redesign of roads to reduce misperception errors. In addition, the Unit's research in this field is reported directly to the Parliamentary Council for Transport Safety by Brown, who chairs its Road User Behaviour Working Group and thus monitors the demand for and implementation of road accident countermeasures which involve legislative change.

# 3.3 MEMORY IN NATURALISTIC CONTEXTS (Project 39) (Baddeley, Bekerian, Bowers, Conway, Dennett, Harris, Logie, Mingay, Nimmo-Smith, Pinto, Wilkins, Woodhead)

An underlying theme of the Unit's approach has been an interest in attempting to study cognition in field experiments in order to supplement and extend work done in the laboratory. For instance laboratory research by Woodhead and Baddeley (1979) indicated that a photograph of a face led to better subsequent recognition when it was initially shown as a three-quarter view than as a frontal pose or a profile. This result was explored by Logie and Baddeley in a series of experiments in which members of our subject panel were given photographs of people represented in one of these poses, and required to search for that person in the crowded streets of a city. Early experiments simply demonstrated that this task is extremely difficult; later studies showed that although the predicted order of difficulty held, the difference between frontal and threequarter view was not sufficiently large to justify recommending that the current preference for a frontal view in passports should be changed. Other everyday memory studies have included a series of experiments by Pinto and Baddeley on how people remember where they parked their car; which proves to be an interesting example of a long-term recency effect such as has been studied frequently in the memory laboratory but rarely in real life (286 U). A series of three experiments indicate that the forgetting observed fits a temporal discrimination model rather than a classic trace decay or interference theory. Baddeley and Nimmo-Smith studied the forgetting of examination material by physiotherapy students who are required to learn anatomy in some detail in their first year. Retention over a period of years was studied, the results having implications both for models of forgetting and also for the design of the physiotherapy curriculum.

## 3.3.1 Remembering to do things

Conventional tests of memory are retrospective in that they prompt the recall of material that has previously been learned (23). In a series of experiments people have been required to remember prospectively without such a prompt. In one study of this kind Harris and Wilkins (137) required their subjects to remember to make a response at regular intervals, while watching a film. They found that forgetting could occur within seconds of showing the intention to respond. While this area of "prospective memory" is difficult to study, it is of considerable practical importance [c.f. research on reminding patients to take pills (see Section 3.4.4) and on memory lapses reported by head injured and elderly subjects (320)].

In a study undertaken by Wilkins in collaboration with the Montreal Neurological Institute, patients with unilateral cortical excisions were instructed to remember to perform a subsequent test in a certain way. Many of the patients failed to remember to act upon this instruction at the appropriate time. These patients included those with left temporal and left frontal lesions, but not those with homologous lesions of the right hemisphere (263 U).

## 3.3.2 Eyewitness testimony

The emphasis of this work has been on discovering techniques whereby the recall of eyewitnesses might be more accurate and reliable (39; 44; 57; 45; 46; 48; 51; 235; 296). A series of studies by Loftus in the U.S. showed that a witness's memory of an event may be distorted by information surreptitiously included during subsequent questioning. Once the distortion had occurred, Loftus reported that the information appeared to be no longer available, suggesting that it had been destroyed. Bekerian and Bowers (44) showed that the old information could be retrieved, provided the order of subsequent questioning followed the order of the events originally experienced. This result is important for two reasons; at a theoretical level, it argues against the position taken by Loftus, namely that new information destroys the memory trace of old, suggesting instead that it merely makes it less accessible. Secondly it has obvious implications for optimal methods of questioning eyewitnesses. One application of this work is to problems of accident investigation. Bekerian has been invited to present this work to professional investigators, and this has led both to collaborative work with Dr. John Rolfe of R.A.F. Training Command, and plans to carry out experimental research using simulators at the Institute of Aviation Medicine (51; 296).

## 3.3.3 Memory for personal experiences

Bekerian and Conway are developing a theoretical framework for memory of personal experiences. They are attempting to relate personal memory to other forms of memory (241), to discover how personal memories might be organised (76 U), and to reveal dimensions of experience that might influence the saliency of a memory (42 U; 47 U). One of the dimensions of experience that has been emphasised has been the emotional nature of the experience (42 U; 77 U).

#### 3.3.4 The cognitive representation of emotions

Current research by Bekerian and Conway concerns the basis for the semantic representation of emotions. Their findings indicate that emotions such as love, anger, fear and joy may form the core of a semantic category of emotions. In a series of six studies they investigated the internal structure of this semantic category. Their central finding was that there were highly identifiable sub-groups of emotions for example; love, joy, happiness and pleasure; hate, anger and jealousy; fear, terror and panic. Further, emotions within a sub-group share many features in common, that is they tend to involve the same people, situations, events, and topics. Features common to one sub-group did not overlap with features from other sub-groups. It appeared that emotions from sub-groups were closely associated with schematic memory representations containing likely contextual information about the conditions for the experience of a specific emotion. The theoretical implications of this research are that specific emotional experiences may be a product of some general form of emotional arousal being interpreted by an appropriate schema. This however, may work in both directions so that activation of a schema, perhaps by environmental events, may lead to a specific emotional experience.

## 3.4 COGNITIVE DEMANDS OF ALTERNATIVE INFORMATION FORMATS - LEAFLETS, TABLES, FORMS AND INSTRUCTIONS (Project 9) (Hull, Lickorish, Poulton, Wilkins, Wright)

## 3.4.1 Design of information

Recent APU work on written technical information spans both comprehension and production. As usual, research has focussed more on readers than writers; but it is recognised that improving the design of written

information requires making the growing knowledge about readers available to writers in a way that they can assimilate and operationalise. Our research suggests that lists of recommendations in the form of "guidelines" are an inadequate solution to this problem (439). As an alternative, we are seeking to develop heuristics which encourage writers to ask certain kinds of questions during the design process (436), and to incorporate evaluation techniques into this process (440).

The information domains which have been addressed continue to be diverse. They include: numerical tables (428); forms (432; 447); drug labels and other verbal instructions (425; 446; 448; 454); lengthy electronic texts (444 U; 445). Research within these domains will be discussed below as separate projects. One factor uniting the research activity in these diverse areas is our development of a three-part framework for "reading" which emphasises the reader's need (a) to understand the way the information is organised, (b) to interpret appropriately specific items of information (whether words, sentences or cell values in a table) and (c) to apply the knowledge gained from reading (427). This approach contrasts with traditional studies of reading which are usually focussed on category (b) (431). Only from the broader perspective do the communalities among people's strategies for handling various classes of information become apparent (433).

## 3.4.2 Numerical Information

When people use numerical tables, the inferences and assumptions they make about the organisation of the information can critically determine how easily the information can be understood. Wright, Hull and Lickorish have shown this to be true for simple lists, which explains why it is difficult for people to check whether their Premium Bond has won a prize (451). It also holds true for more complex matrix structures such as the departure information in airport lounges or tables in textbooks (451). We are now extending these studies to include data graphics. This development was prompted by the practical problem of explaining to jurors the intricacies of complex fraud trials, but the issues raised are of relevance to a much wider audience Including business and commerce, management and education. Because of the growth of software packages which integrate tabular and graphic displays, plans are in hand to develop more collaborative research with external organisations having an interest in this area of numerical data presentation.

#### 3.4.3 Electronic communication

Increasingly we have been concerned with the impact of the new information technologies (429). These provide both a design resource and a novel communication medium having its own limitations and potential (437). There are some interesting trade-offs to be computed when deciding whether to design a system to fit the users' anticipated needs, or whether to teach users how to recast their requirements so as to exploit the system's characteristics (445).

A major external collaboration during the past four years has been through participation in the British Library Electronic Network Development (BLEND). Here the domain of interest was scholarly texts. Wright and Lickorish have examined the difficulties people have dealing with scientific reports on a CRT when working as readers (Wright (U)), proof-readers (452; 453) and scholarly reviewers (454). These studies have demonstrated the critical importance of the incidental processes which accompany reading (e.g. page turning and the use of spatio-temporal information) (455). Our findings have also shown how closely the activity of writing (e.g. annotating a text) may be interwoven with academic reading. Plans are in hand to extend this focus on the information handling skills of academics to explore the organisation by individual scientists or their own information files (data sheets, reprints, correspondence, etc.). These skills can in turn be related to cognitive activities such as report writing. The payoff from these studies is bi-directional. Not only does the outcome increase our knowledge of cognitive processes, but it also indicates some of the design requirements for information technology systems.

## 3.4.4 Verbal instructions

Although we have shown that people will deliberately ignore written directions in certain circumstances (425; 446), there has been considerable interest shown by outside organisations in what we might be able to contribute to improving the design of computer documentation. Using the three-part framework outlined earlier, recommendations have been made about the design of user-oriented documentation (427; 434; 435; 436). But there often remain organisational difficulties in combining the various design skills needed and in selecting appropriate evaluation techniques (440).

Collaboration by Wright and Wilkins with M. Allwood of Addenbrooke's Hospital pharmacy department has led to some survey work on the general public's understanding of drug labels. The early results show cause for concern. Converging techniques are now being used to check the validity of the first survey results. It is hoped that external funding may be found to extend this investigation to locations outside Cambridge.

## 3.4.5 Geometric illusions in reading graphs

Poulton has shown that the reading of a point on a graph is influenced by the slope of a line passing from the point in the direction of the calibrated edge against which the point is read. The sloping line is taken to be closer to the horizontal or vertical, whichever is the nearer, and the reading is biased accordingly. A number of sloping lines lying between the point and the correct reading on the calibrated edge increases the size of the geometric illusion (295 U).

## 3.4.6 Bias in quantifying judgment

A person may be asked to make quantitative judgments on dimensions where he has no familiar arithmetic units that he can use. If so, his judgments are likely to be biased in a number of ways. These are described by Poulton in a forthcoming book (291). The aim is to point out to people that the biases occur, and to indicate the nature and sizes of the biases. Methods are proposed for abolishing or minimizing the biases (289; 292; 293 U).

A further study by Poulton is concerned by the biases introduced by influential companion conditions included in a within-subjects experimental design. The whole object of experimenting in the laboratory is to get away from variables that bias the results in unknown ways. Using a within-subjects design puts back the variables, all neatly balanced for subjects and order, but still biasing the results in unknown ways as a result of asymmetric transfer (290; 294 U).

## 3.5 PERCEPTUAL AND CONTROL PROBLEMS IN TELECOMMUNICATIONS SYSTEMS (Project 7) (Brown, Copeman, Wastell)

Most of the research on this project derives from regular contact with British Telecom's research staff, under the longstanding BT/MRC consultancy arrangement, although not all the work is funded by the consultancy. A number of studies simply reflect the Unit's continued concern with various ergonomics aspects of system design, field research on which is facilitated by collaboration with BT staff. For example, this arrangement permitted a series of psychological studies to be conducted into the effects of changing technology on telephone operators' attitudes, skills, performance and response to task-stress (67; 68). Advantage has also been taken of such collaborative research to investigate certain methodological techniques for collecting performance data in working environments. Brown has proposed further research on operators' responses to technological change; including an examination of new methods for assessing performance in complex and rapidly-changing systems. This will be considered for funding by BT in 1986.

Work under this project is often extended to cover more general issues relating to the performance of people in technological systems. For example: Brown has published review papers on ergonomics contributions to product and system design (60) and on methods for assessing mental workload among system operators (58). More recently, attention has been given to the broader issue of information technology and its consequences for the Individual and society. Brown has chaired a Working Party set up by the National Electronics Council to examine such issues and their report was published in late 1983 (66). It contains detailed recommendations for everyone involved with information technology, from Central Government to end users. The aim of the report is to ensure that the full benefits of the new technology are realised. Brown has also recently reviewed the implications of changing technology for the subject and professional practice of ergonomics (62).

## 3.6 EXPERT SYSTEMS (Project 49) (Gammack, Johnson-Laird, Young)

The main effort of Young in this area has been on the topic of Knowledge Elicitation, which is concerned with how the knowledge possessed by human experts can be discovered and represented in a form suitable for coding into an Expert System. As part of a European Community ESPRIT-funded project in collaboration with Scicon Ltd., we reported on the techniques available (72). Young is the supervisor of an SERC CASE studentship held by Gammack and sponsored by Unilever Research for the study of knowledge elicitation. The reports so far (111) stress that expertise depends on several different kinds of knowledge, and aims to match the characteristics of the elicitation technique to the type of knowledge. We also criticise the underlying metaphor of many approaches to knowledge elicitation as being one of mining rather than measurement, and propose instead that "knowledge can be probed but not quarried."

In addition to knowledge elicitation, other human interface aspects of Expert Systems are of interest (459; 461). Some Expert Systems can act as quasi-intelligent agents, they raise new questions, such as the role they play vis-a-vis the user, whether as slave, boss, assistant, or colleague. Such questions have a direct bearing on the fundamental design of the system. Young also recorded a one-hour videotape on the use of production systems in Expert Systems (460), as part of the Alvey IKBS Awareness Programme.

As a stepping stone towards the implementation of small expert systems on micro-computers, Johnson-Laird has implemented an advice-giving program on BT's Regent Call-Connect telephone system. Two versions of the program have been devised: one written in LISP-80 runs (very slowly) on a Zenith Z-80 based machine, and the other written in MuLisp runs efficiently on the ICL 16-bit personal computer. The next stage of the project will be to Implement a small-scale natural language parser to act as an interface with such advisory systems. ICL have expressed interest in the project and lent the ICL machine for MuLisp implementation.

## 3.7 HUMAN COMPUTER INTERACTION (Project 38) (Barnard, Conway, Craven, Grudin, Hammond, Hinton, Hull, Jorgensen, Long, MacLean, Morton, Norris, Wilkins, Wilson, Young).

Although the need for research on "man-machine interaction" has recently been brought into prominence by the government's Alvey programme, APU has emphasised this area for some time. During the period covered by this progress report a number of projects have been completed and yet others started up. The unit's research collaboration with IBM has been increased and extended. In 1980, a second three year programme was initiated with IBM's financial and technological support. This project was primarily aimed at increasing our understanding of the kind of cognitive problems encountered by new users of office technology. For this second project the core APU team involved Hammond, MacLean and Barnard. However many of the studies involved additional collaborative effort both from within APU (Morton, Hinton) and from outside (Clark from IBM; Jorgensen from Denmark; and Long from University College, London).

As a research programme which sought to form bridges between laboratory and applied problems a number of related studies were carried out. In order to identify the kinds of problems actually encountered by computer users, their performance with commercially available office systems has been systematically monitored and analysed (129; 203; 202; 127). These studies showed guite clearly that users frequently had difficulty understanding, learning and remembering the kinds of terminology, dialogue structures and "conceptual models" often incorporated into current forms of computer "interface" (131). Particular problems have been extensively studied in laboratory simulations of key design features with a view to understanding the underlying causes of user difficulties. Individual studies have examined the learning of different terminologies for text editing commands (36; 37); the effects of different kinds of dialogue structures, styles, and task demands (34; 35; 130); and the influence on user memory of alternative ways of building mental representations of sequences of computer commands required to complete extended tasks (38). This particular research programme has not only sought to provide appropriate cognitive analyses of user behaviour. The project team have sought to form firmer bridges to the problems of application by synthesising results across observational and experimental data (126), by abstracting the conceptualisations of computer system designers from interviews (128), and by studying their detailed design decisions (179). It has also paid particular attention to the problems of interpreting experimental data (30; 210), applying the output of cognitive research (31), and the development of pragmatic methodologies for evaluating design trade-offs (125; 211 U).

Work originating on the IBM project has also been carried over to other projects. With additional support from British Telecom, the particular problems of terminologies for computer commands were pursued in some detail by Grudin and Barnard. Evidence was sought to help clarify the conceptual problems of the "naturalness" of alternative types of computer commands and a "cognitive demand" analysis of the underlying problems proposed (123). Abbreviation schemes for computer commands were also examined in some detail with particular reference to the past experience of the user population (122; 124). Similarly, Barnard provided support to apply some of the theoretical analyses of human computer interaction to the problems of naval command and control systems In a collaborative effort with the software house Scicon (135).

IBM has again extended its support for APU's research programme and a third three year project was started last year. In this project Barnard, MacLean and Wilson are focussing on the new generation of "integrated" office system which combine several applications (eg. word processing, filing, spreadsheets, graph production etc) into unified systems with a common conceptual interface for the user. It is also focussing on the longer term acquisition of knowledge as users progress beyond the stage of being complete novices. As with the previous projects this involves the development of applicable theoretical ideas (33 U), observations of real systems (413 U), and a series of laboratory experiments. Since cuts in MRC expenditure are likely to jeopardise our ability to operate at the leading edge in this area, particularly in relation to the provision of appropriately advanced computer equipment and software, we are currently exploring additional sources of external financial support to develop this research programme.

In addition to conducting the research itself, APU has played host to a large number of commercial and academic visitors and our staff have contributed to relevant committee work both at a national and European level concerning the future of research on Human Computer Interaction.

The application by Young of earlier ideas about "cognitive compatibility" between user and system to the design of viewdata menu frames, funded by British Telecom, has uncovered the importance of the "classification structure" of a frame for its usability (464; 465). It can be shown that different ways of dividing the topic dealt with by a frame Into subtopics logically require the user to adopt different decision procedures, depending on, e.g., whether or not the subtopics can overlap. The use of an inappropriate decision procedure leads to confusion and errors. Present work is investigating other factors affecting the user's decision, the aim being a. computer simulation model of the process of choosing an item from a viewdata menu.

A description of the force-sensitive platform we designed for use with the viewdata studies has been written up for general publication (463). Young's earlier work on users' conceptual models of interactive devices (457) has continued into the present reporting period, with an application to the problem of controlling ill-defined systems (458).

Over the last three years, Young's work in HCI has been spent less directly on research than on the extensive research planning activities associated with the government's Alvey Programme for research in advanced information technology, especially the part dealing with MMI (Human-Machine Interface/Interaction).' As well as acting as link between two of the advisory boards. Young contributed to the drafting of the SERC/Department of Industry (1983) report on "The Alvey Programme - A Proposed MMI Strategy", which in turn formed the core of the Alvey MMI strategy document. Similarly, Young wrote the report (461a) on "Cognitive processes of the individual" as part of the Human Interface Research Planning workshop, which led to an Alvey announcement of opportunities for research in this area. In collaboration with a colleague from British Telecom, Young organised and reported (295a) the first joint workshop on research in MMI and IKBS ("Intelligent Knowledge Based Systems").

[See also (459; 461) under Project 49: Expert Systems].

## 3.7.1 Cognitive factors affecting the use of information retrieval and text editing systems

Increasingly more people use computerized large scale information systems both at work and in the home. However such systems although relatively easy to use do not necessarily provide easy access to the soughtfor-information. Young and Hull showed that one reason for this is that there may be a cognitive mismatch between the user and the way information is organized in the system (465). In a series of studies, Conway and Norris investigated what level of abstraction of the sought-for-information helped in a) producing a response which matched information in the system, and b) allowed subjects most freedom in terms of how they wished to search the system. The central finding was that there was a 'basic' level of abstraction which equally facilitated the user searching for more abstract or more specific information. Also at this level people were more likely to give predictable initial responses. In the next phase of this research we plan to examine how different problem statements may affect the type of search the user intends to undertake and how feedback from the system, in the form of basic level information, may interact with the problem statement. The central goal of this research is to specify a number of purely cognitive factors which designers of information systems may employ to facilitate the efficient use of such systems. This research was financed by British Telecom (78 U).

Work by Norris has focused on the organisation of the 'help' system in a simple text editor and on the effects of transfer from one set of command names to another. In the context of the simple system, transfer from one well selected name set to another shows remarkably few problems. This appears to be due to the ease with which people can keep track of the 'old' and the 'new' name sets. We are currently investigating the transfer problem under conditions where the task of keeping track of the old and new name sets will be more difficult.

## 3.7.2 Expert knowledge of programming concepts

Much recent research has investigated how expert programmers differ from non-expert programmers. Obviously this is a particularly important problem for educationalists and for the development of programming languages. However the findings have generally been unimpressive merely indicating that experts have richer conceptualizations and attend to different aspects of programming languages. Further, the majority of studies have focused on numeric as opposed to symbol processing languages. It would seem that a focus on symbol processing languages is currently required given that the fifth generation computers will employ such languages. The present project started with two specific aims: firstly to investigate differences between experts and secondly to focus on LISP programming. In a concept classification study, Conway found that lisp experts created very similar low level groupings of concepts. However when the experts were required to amalgamate their low level groupings into higher order groupings markedly idiosyncratic groupings emerged and there was little overlap between experts. This initial finding suggests that experts may share a common low level knowledge base but differ radically in terms of higher order constructs. The next phase of this work will focus on how these higher order constructs are brought to bear on specific programming' problems.

## 3.7.3 Psychological aspects of programming and using computers

This project commenced October 1984 with the transfer of Green from SAPU to APU. A model of the user's representation of the language for interacting with the computer, previously developed by Green and Payne, will be extended into a computational form, and attempts will be made to predict in advance how the user's representation distorts the intended language, whether the language will be easy to learn, and where slips and errors will occur frequently. Relationships between this model and recent developments in context-free grammars of natural language will be explored. An overview of some of the problems is given (117).

## 3.7.4 "Eye-strain" and visual display units

Visual display terminals have been associated with reports of "eye-strain" and headaches, and this is causing widespread concern. The complaints remain largely unexplained, although there are now several studies showing that reading from such displays is slower than from printed text (452).

Visual display units typically use cathode ray tubes that are intermittently illuminated at frequencies above those at which flicker is perceived. Wilkins has shown that this intermittency affects the control of eye movements, making the high-velocity movements about 10% larger than they would otherwise be, and increasing the number of corrective movements (383 U). The interference with ocular motor control may help explain the slower reading on visual display units, and perhaps also the complaints of "eye-strain", given the possible existence of a link between eye movements and headaches (381).

The above work has been supported by the Electricity Council Research Centre (Capenhurst) who supplied funds sufficient for the purchase of the eye movement recording equipment, and IBM UK Ltd. who donated a personal computer with analog-digital converter necessary for the data collection and analysis. Further support is being provided by a consultancy agreement with the Electricity Council Research Centre, and by IBM UK Ltd. who have contributed to a studentship held by Craven under the partnership awards scheme.

## 4. HEARING

## 4.1 THE DISRUPTION OF AUDITORY PROCESSING BY NOISE (Project 22) (Lutfi, Milroy, Nimmo-Smith, R.Patterson, Weber) (Partial funding from RAE, ISVR, and the CAA.)

It is important to be able to predict the intensity that speech or an auditory warning signal must have for it to be audible in a particular noise environment such as an aircraft cockpit or a hospital ward. Previously, this led R. Patterson and Nimmo-Smith to develop a quantitative model of auditory masking based on the concept of an auditory filter bank; that is, a set of adjacent linear bandpass filters that divides incoming sound into separate frequency channels. The success of the model depends primarily on the accuracy of our representation of the shape of these auditory filters. In this reporting period we determined the shape of the filter as a function of age (284) and stimulus intensity (209), and demonstrated that the shape measurements are not confounded either by the detection of auditory distortion tones (208) or the variability of the masker (379). We also developed a new mathematical description of the filter whose complexity increases as the data require (283) and showed that 1t provides surprisingly precise predictions of the masking levels in the laboratory and on the flight decks of civil aircraft.

The success of this 'Roex' model has led to a set of collaborations with the Royal Aircraft Establishment in Farnborough and the Institute of Sound and Vibration Research in Southampton to predict auditory masking in helicopters -- a particularly difficult type of noise environment. The initial project consisted of three masking experiments including one in a full-scale helicopter simulator, all supervised by APU. It showed that the Roex model could predict listener's threshold to within the accuracy of the noise measurements using population parameter values obtained from the literature. The project report is being prepared currently and includes a microcomputer version of the Roex model to make it more generally available. A direct extension of the project to predict masking in civil helicopters has now been undertaken by the Civil Aviation Authority, again under our supervision. The Navy Applied Psychology Unit at Teddington has asked us to assist in adapting the model to predict masking in naval sonar rooms and the model also provided the basis for a chapter on Voice Communications written for the Navy (278).

A comprehensive review paper that summarises research on the measurement and application of auditory filter-shapes has been written by R. Patterson in collaboration with Dr. Moore of Cambridge University (282).

## 4.2 THE DESIGN AND EVALUATION OF AUDITORY WARNING SYSTEMS (Project 21) (Edworthy, Milroy, R.Patterson, Shailer) (Partial funding from CAA. RAE, and ISVR.)

The auditory warning systems currently used in transport vehicles and hospitals cause considerable irritation and confusion. There may, for example, be as many as 15 auditory warnings on the flight-deck of a civil aircraft, all of which are too loud, and as many as 50 in the intensive care ward of a hospital, most of which are simple high frequency tones. Previously this led us to determine the appropriate level and number of warnings for a civil aircraft warning system at the behest of the Civil Aviation Authority (CAA). This has generated a series of collaborations in the current reporting period.

A set of guidelines for the design and evaluation of auditory warning systems was written by R. Patterson for the Civil Aviation Authority, which they published as a position paper (275; 277). The principles embodied in the guidelines were illustrated by reviewing the auditory warnings in two current aircraft, the BAC 1-11 (279) and the Boeing 747 (280), and by reviewing an international proposal for auditory warnings in future aircraft (275). The guidelines have since been used to develop a CAA standard for auditory warnings on airlines flying into Britain.

We drew the MRC's attention to the commercial potential of our auditory warnings research and together we filed four patent applications for auditory warning systems through the British Technology Group (BTG) (UK 8222029, UK 83202U4, Europe 83304350.8, and USA 515501). A license to produce warning systems under the patent was taken out by Racal Acoustics and it has generated about £20,000 to date.

We developed a standard for auditory warning systems in hospitals in conjunction with a group of consultant anaesthetists operating under the auspices of the British Standards Institute. This work precipitated the formation of a working group of the International Standards Organisation with whom we have prepared a draft international standard for the Rationalisation of Auditory Warnings in Hospitals. The APU guidelines form the basis of all documents and they are about half way through the standardisation process.

The Directorate of Helicopter Projects (MOD) have asked us through RAE Farnborough to prepare a specification for a standardised set of auditory warning signals in military helicopters based on our masking studies and our guide!ines work.

The warning sounds specified 'in the draft standards of the CAA, the BSI/ISO, and DHP are unlike any previous warnings and it is difficult to describe them in words. As a result, all three groups have asked APU to prepare demonstration warning sets to illustrate and promote the relevant standards. These warning sets will also be used for field trials in hospitals and aircraft, and with the appropriate modifications, will probably become the first of the new generation of computer based auditory warning systems. The OHP warnings are essentially completed, the CAA warnings are in preparation, and funding for the hospital warnings appears imminent.
The collaboration associated with Project Numbers 22 and 21 have been particularly important for the Auditory Group at APU: Firstly, they enabled us to test the Roex model via laboratory and field experiments that we were not able to perform technically and for which we did not have the staff. Secondly, they enabled us to extend the influence of our research and theories in a controlled way, again without taking on extra staff. Finally, they provided the resources to expand the auditory laboratory at APU over this period (roughly £22,000).

# 4.3 IMPROVED AUDIOMETRY ASSESSMENT (Project 3) (Terminated 31.3.84) (Milroy, Nimmo-Smith, R.Patterson, Weber)

It is generally assumed that the standard hearing test, the audiogram, should be accompanied, if not surplanted, by a test that reflects frequency resolution rather than just absolute sensitivity. As a result, we have developed a clinical version of the auditory-filter measure and carried out a population study to establish norms for the Roex filter shape for middle-aged and older people (284). The study was extended to show that the filter-shape measure could predict speech intelligibility results better than the audiogram (283). Subsequently, we have collaborated with Cambridge University to establish a more powerful test that can be used to measure asymmetry in patients' filter shapes (116), and with the MRC Institute of Hearing Research in Nottingham to demonstrate that some patients have abnormally asymmetric filters (335). In particular, we found patients who suffer from the downward, rather than the upward, spread of masking and who would actually be hindered rather than helped by standard hearing aids.

# 4.4 PSYCHOLOGY OF MUSIC (Project 50) (Edworthy, R.Patterson)

The ability of musicians and non-musicians to discriminate between major and minor chords is currently being studied by Edworthy and R. Patterson. Reasons for this study are twofold. First, the major/minor dichotomy warrants investigation because of its status in Western music; secondly, it 1s being used to study the interaction between key and interval information at a cognitive level, for which no adequate theory currently exists.

When we listen to a melody, which repeats at a different pitch, it may either preserve the key, in which case the intervals must change, or preserve the intervals, in which case the key must change. Key and interval information are mutually dependent as a key cannot be established without intervals, and intervals appear to be more precise when a key can be established (96; 97). Examples of both sorts of invariance commonly occur in music.

There are specific instances of pitch changes for which a preservation of key results in a mode change from major to minor, or vice versa. These changes do not appear 'incorrect' because the key has been preserved. We have crystallised this phenomenon into a series of two-chord Interference studies, where a sense of key can be induced by fixing the pitch of the second chord. Initial data show that when a mode change occurs, but the key is preserved, judgments of mode are more difficult to make than when there is no such conflict of tonal and modal information.

Further experimentation will develop this paradigm to include longer chord sequences, and melodic sequences. 4.5 CENTRAL AUDITORY PROCESSING (Spiral Processing of Sound) (Project 51) (Limbert, Lutfl, Milroy, Nimmo-Smith, R. Patterson, Peters) During this reporting period R. Patterson discovered a 'spiral' method of extracting pitch from streams of auditory nerve pulses, which appears to be more sensitive and more economical than current methods. It has important implications for both hearing theory and automatic speech recognition and so a new project was initiated to pursue the discovery.

About 10 years ago three different models of pitch perception were published all of which suggested that the mechanical spectral analysis performed by the cochlea might be sufficient to account for the majority of pitch-perception phenomena. Although these three models still dominate hearing theory, it has become apparent that the timing information observed in the phase-locked fibers of the auditory nerve also plays a role in determining pitch. Indeed, it now seems that this temporal information may be the more important factor in the case of musical pitch and speech pitch, and that the primary purpose of the cochlea is to alleviate masking; that is, to prevent the disruption of high-frequency signals by low-freqency noise and vice versa. As a result, attention is now focused on auditory neural processing in the hope that it will provide the basis for a better understanding of speech recognition processes and music perception.

There is a stark contrast in hearing research between our understanding of the mechanical analysis of sound performed by the cochlea and the neural analysis of sound performed by the brain. Whereas there are competent simulations of basilar membrane motion to explain how the cochlea performs its spectral analysis, there are only primitive histogram models to suggest how the brain might extract pitch from the regularly spaced streams of nerve pulses observed in phase-locked auditory fibers when the ear is stimulated by a periodic sound.

Several years ago R. Patterson discovered a spiral mechanism that can convert the timing information in a regularly spaced stream of pulses into a spatial pattern of spokes radiating from the centre of the spiral. This Spiral Processor appears to have the right properties for extracting pitch from neural impulse streams quickly and passively without the need of harmonic templates or sieves. Briefly, the time line along which the nerve pulses flow is wrapped into a logarithmic spiral with base 2, and the nerve pulses flow from the centre of the spiral outwards. For a periodic wave, once per cycle, the nerve pulses coalesce onto a specific pattern of spokes and the orientation of the pattern determines the pitch.

The Spiral Processor appeared to represent a major breakthrough for automatic speech recognition machines, the commercial market for which is estimated to be in the hundreds of millions of pounds in the next decade. To demonstrate the advantages of the Spiral Processor a thirty-filter simulation of the cochlea was programmed on our sound computer and used to convert incoming sounds into the types of pulse streams observed in primary auditory nerves. A thirty channel Spiral Processor was then programmed on the same computer to extract pitch from the ensemble of pulse streams and a dynamic display of the pulse streams flowing along thirty concentric spirals was assembled.

For commercial reasons the project was kept strictly confidential until it was presented to the Industrial Liaison Group of the MRC in June of 1984. A patent application for the spiral sound processor was then developed and filed on January 2nd, 1985 to establish our commercial priority. On January 3rd, 1985 a paper on the spiral processor was presented at a meeting of the Experimental Psychology Society to establish our scientific priority in this area. Research on pitch and periodicity perception had already begun in the current reporting period before the Spiral Processor was discovered. A pair of studies were performed to show that low pitches like those associated with the vowels of speech are much easier to perceive in short sounds when the fundamental is accompanied by higher harmonics, a finding that supports a temporal theory of pitch perception (285). A subsequent series of experiments on the detection of a repeating tone burst presented in a repeating noise indicated that the high-resolution version of incoming sound produced by the cochlea is reduced to a much lower resolution form within 100 ms of its capture (281). Finally, a series of experiments was performed to investigate the perception of repeating noise and determine whether spectral theories were correct in their assumption that the perception of repeating noise. The data make it clear that the spectral theory is decidedly incorrect but they did not suggest an alternative temporal mechanism (195).

# 5. MOTOR SKILL AND ACTION

# 5.1 CONTROL AND TIMING OF MOVEMENT (Project 41) (Grudin, Hinton; Long, McLeod, Nimmo-Smith, Wing)

In a review of the literature Wing (415) found general support for the concept that accurate movement of the hand to a target takes place in two phases. An initial phase serves to cover distance rapidly while a second phase employs feedback to correct any discrepancy between actual and Intended hand position at the end of the first phase. A project being carried out in collaboration with Dr. Miller at Addenbrooke's Hospital is examining the relation between the two phases of movement using a procedure in which a discrepancy between hand and target is unexpectedly introduced by the experimenter in the course of the movement. In one study similarities in timing of movements in the two phases were found even though there were large differences in the amplitude of movement, (420). One interpretation of this result is that a single motor programme underlies both phases of movement. This idea is now being explored further by looking at corrective movements initiated at different points in the initial, distance-covering phase of movement. In real life, movements are often made very quickly with no opportunity for feedback correction. A movement made without correction is called ballistic. In reaching for an object in the environment, vision is normally used to guide the hand so that the fingers encompass the object as the hand closes. However, if the movement must be made quickly such guidance is not possible. Wing, in collaboration with Turton and Fraser at Addenbrooke's Hospital (424 U), found that people compensate for the loss of feedback correction by opening the hand wider as it approaches the object so giving a greater margin for error.

McLeod et al (224) studied the timing of fast, ballistic movements used in hitting a moving ball with a bat. They observed a remarkably low degree of temporal variability in' the movements - less, for example than is found in typical reaction time tasks. They suggested that the low variability might be due to a task-specific process that operates unaffected by other, competing demands for information processing resources. This represents a particular theoretical view of the attention demands of movement; a general review of such theories may be found in (143). One of the most serious theoretical problems in developing theories of motor control is the number of degrees of freedom involved. Computational models produced in robotics and artificial intelligence seem in general inappropriate as psychological models because of the long sequence of accurate numerical operations they require to program an appropriate movement. Hinton, in work performed while he was here developed a computational model which is much more psychologically plausible. The style of computation involved is iterative approximation using separate parallel processes for each degree of freedom. He showed that the number of iterations required can be greatly reduced by. adding processors that coordinate several joints at once.

The development of psychological theories about the control of movement is often aided by study of changes in the nature of performance with increasing skill. Long et al (204) documented the way in which the intervals between keystrokes in typing reduce with practice. On the basis of a detailed statistical analysis, they suggested two distinct processes were involved in generating the timing data, one responsible for fluent and the other for non-fluent keystrokes.

Other work on typing has focussed on the nature of errors in typing rather than the timing of keystrokes. Grudin (119) found that novice typists produce not only more errors but also a different pattern of errors from that produced by experts. He concluded that the differences were consistent with the development by the skilled typists of action units comprising several keystrokes at a time. It is interesting to note that, even among skilled typists, there is not just one pattern of errors; Indeed, as Grudin (121) has pointed out, error patterns are characteristic of the individual, and hence they should be of forensic interest.

Grudin's evidence of multicharacter typing units may be seen as a particular case of the general point made in (109). Performance of a sequence of movements usually involves more than just the stringing together of individual components. People impose structure on the sequences they perform to integrate the separate movements into a smooth, coordinated flow of action. In the area of movement control a frequently encountered candidate for describing -the structural relations between elements in a sequence of movements is the hierarchy (316; 317; 318). However, in the case of typing, Grudin (120) found the pattern of errors was not consistent with a hierarchical specification of finger movements.

In the motor skills discussed above, timing is not an explicit component. However satisfactory musical performance or interpretation does require accurate placing of movements in time. Using the simplified laboratory task of regular repetitive tapping as a model for more complex skills such as piano playing, Wing (414) presented a theoretical account of coordination of simultaneous two-handed tapping data based on a single central timekeeper. However, when the timing task involves two, asynchronous response streams such as two hands tapping in alternation, Wing, working in collaboration with Dr. Don Gentner, University of California, San Diego, has observed a degree of independence in the timing of movement In each stream. This is counter to the single timekeeper theory and is currently the subject of further investigation.

### 5.2 HANDWRITING (Project 10) (Eldridge, Nimmo-Smith, Wing)

Much of our research on handwriting has been concerned with its use in the applied area of identity verification. If handwriting in two documents, one of known origin the other perhaps unearthed in some criminal investigation, is similar, it may mean the two documents were written by the same person. But, in

coming to a conclusion on this, a potential problem is that handwriting is inherently variable. To make reliable judgments, the forensic document examiner needs to know not only which handwriting features people produce in different ways but also whether they are produced consistently on different occasions. Under a contract with the Home Office to provide objective data in this area (422), Wing, Nimmo-Smith and Eldridge collected and analysed a set of cursive handwriting samples. A scheme for the classification of a selected set of cursive letters was developed and used to describe handwriting variability in terms of a discrimination index that summarizes variability within any one individual's handwriting relative to the variability observed between individuals. This index was used to rank the potential usefulness of different features of various letters, (98). Further analyses were run to determine the statistical dependence between different features. Such dependence affects the way in which the document examiner should combine evidence from different features in arriving at a single decision about authorship of a questioned document, (99).

The text used in collecting the handwriting samples included words with certain letters occurring at the beginning, middle and ends of the word. Wing et al (423) reported an analysis showing that the average variability of letter formation within the writing of a given individual is greater at the beginning than at the middle or end of a word. This implies that, in cursive writing, the basic model form for any letter is modulated to facilitate joining with the following letter.

Although statistically reliable, the magnitude of the effect reported was small (423), and it is possible that children, who have less firmly established internalised letter models, would be likely to display more letter form variability in letters at the beginning of words. Samples of children's handwriting have been collected by Wing and Nimmo-Smith in collaboration with a calligrapher working in Kent schools, Mrs. Rosemary Sassoon. Photographs of the children's pen grips were also taken in order to investigate a further issue: Training of handwriting as a motor skill receives little emphasis in school these days and, as a result, children tend to use a proliferation of writing grips. We are interested in determining how the nature of pen grip used affects the child's quality of writing.

A consultancy in this area was carried out in 1984 by Wing and Nimmo-Smith for Scicon on the human factors of automatic signature verification.

# 5.3 MOTOR DISORDERS (Project 48) (Lough, Wing)

#### 5.3.1 Recovery of arm function following stroke

Our interest in disorders of voluntary movement is twofold. On the theoretical side Lough and Wing are interested in describing deficits in the control of movement that can be identified with different functional processes and the degree to which extant theories can account for the various types of movement disorder (417). They are also concerned with the more applied question of how function may be improved by changes In physical therapy.

In the U.K. it is estimated that two in every thousand suffer from a stroke each year. Of the 70% who survive, three quarters are left with a severe residual dysfunction of sensori-motor processes. Ten percent of the working time of hospital and community physiotherapists is spent attempting to maximise the recovery in this group of patients. The scale of this affliction in terms of sufferance of movement disability and cost to N.H.S. resources is second only to arthritis. However a review by Lough points out that aside from subjective clinical

experience little is objectively known about the sensori-motor dysfunction caused by stroke, or about how the condition should be most effectively managed.

It has demonstrated that by applying the experimental techniques and theoretical constructs used in the behavioural analysis of normal motor skills to the study of hemiparetic movement, insights can be gained into the problems these patients face, and suggestions can be made as to how therapeutic Intervention might be Improved. This current project expands on these findings through a longitudinal behavioural analysis of recovery of hemiparetic upper limb function (185).

Lough and Wing, in collaboration with Fraser and Oenner of Addenbrooke's Hospital developed a method for assessing voluntary movement in hemiplegic stroke patients with only a minimal degree of movement (207). Data are currently being collected to provide a quantitative picture of the recovery of elbow function. Performance of a given patient is tested in a variety of movement contexts (e.g., with and without - ipsilateral shoulder movement, contralateral arm movement, or vision). Joint angle information and EHG data are recorded over several months of recovery to elucidate how muscle activation patterns change. The ultimate goal of this project is to provide a database on arm recovery from which therapy can be assessed and improved. As the data are still being collected and analysed no firm conclusions can be offered at present. The picture of recovery which seems to be emerging is much more complex than has been previously described. It appears to suggest that current management policy for stroke patients may be failing to contend with problems in movement control which, with a change in therapy assessment and practice, could be resolved.

A symptom often associated with Parkinson's disease is bradykinesia or slowness of movement. The bradykinesia can result in more variable timing of repetitive movement. A detailed case study by Wing in collaboration with Keele and Margolin of the University of Oregon of a patient with bradykinesia affecting one side more than the other concluded the increased variability in timing should be identified with a deficit in timekeeping rather than being due to increased motor delay variability (419). Micrographia or small handwriting is another symptom that can occur in parkinsonian patients. The change in size of writing has been shown by Margolin & Wing (231) to be associated with progressive reduction in the force used for each pen stroke and this reduction in force is not completely compensated by taking more time to complete each stroke. This work plus a review of other studies led Wing & Miller (421) to suggest that the basal ganglia lesions in Parkinson's disease affect the activation of movements that have been correctly programmed and are waiting to be initiated. To explore this hypothesis we are currently testing parkinsonian patients at Addenbrooke's Hospital. One group comprises patients with asymmetric symptoms so that the less affected side may be used as a comparison for the more parkinsonian side. Another study involves the comparison of the performance of patients before and after treatment for the disease. This work would benefit from availability of research assistance; all the paradigm development etc. is complete but patient testing is slow and time consuming. The identification of a particular process or function underlying movement control with a given brain structure is not a prime aim of the present research. Rather we are interested in motor disorder insofar as a selective deficit can be revealing about the nature of normal movement control and also suggestive in regard to possible strategies for therapy. An illustration of this point is a case study carried out with Mrs. Carole Fraser at

Addenbrooke's Hospital involving a girl with an artificial hand (418; 106). Despite mechanical differences between the operation of her natural hand and the artificial hand, it was shown that there were certain very significant similarities in reaching movements carried out with either hand. It was argued that the similarity clarified the reason for stability of the thumb relative to the index finger in the natural hand as the object was approached. A research proposal extending this approach to the training of artificial hand users has been prepared for submission to the DHSS.

# 6. VISUAL PERCEPTION

# 6.1 PHOTOSENSITIVE EPILEPSY (Project 2) (Wilkins)

(a) About 5% of patients with epilepsy are photosensitive and liable to visually-induced seizures. Epileptiform electrographic abnormalities are induced by visual stimulation with certain very specific spatial and temporal characteristics. Wilkins has pointed out that these stimulus characteristics and the topography of the EEG discharges they induce suggest (52) that the epileptic discharge is triggered in the visual cortex of the brain and may be sustained within it (52), and (55) that the cerebral hemispheres may have different convulsive thresholds (53; 384) even in patients with primary generalised epilepsy. The pharmacological evidence (reviewed by Wilkins in collaboration with Or. B.S. Meldrum, Institute of Psychiatry, University of London) indicates that in photosensitive epilepsy there exists a minimal failure of cortical inhibitory processes (arising from GABAerglc or dopaminergic mechanisms), which has no consequences under normal conditions of excitation. When normal physiological excitation exceeds a critical mass, however, the inhibitory processes are unable to prevent the discharge from spreading (233). If the normal excitation is organised in a temporal pattern the epileptic process is facilitated (54).

(b) Television induces seizures partly because of the flicker generated by the flying spot as it scans down the screen, but mainly because of the pattern of interlaced lines (55, 180). This suggests several alternatives for the prevention of seizures by optical methods (385) and has implications for the design of visual display units (380).

(c) In some patients with photosensitive epilepsy, epileptiform EEG abnormalities occasionally appear after a slow closure of the eyes. The EEG changes associated with the epileptiform abnormalities appear before the eye closure suggesting that the eye closure is not simply a mechanism for the self-induction of seizures, as has previously been supposed (342).

(d) The successive lines of printed text comprise a pattern of stripes with characteristics within the epileptogenic range. A simple mask that covers the lines of text above and below those being read attenuates the epileptogenic properties of the pattern and enables patients with photosensitive epilepsy to read without the risk of seizures. The mask is now being sold as the "Cambridge Easy Reader" (385).

(e) In patients who are not obviously photosensitive, movements of the eyes can precipitate paroxysmal EEG abnormalities and this can disrupt reading. The "Cambridge Easy Reader" facilitates the movements of the eyes across text and presumably for this reason can improve reading in patients affected in this way (385).

(f) A study in collaboration with Dr. Zifkin and Dr. Andermann at the Montreal Neurological Institute has shown that in some patients seizures may be induced by mechanisms that are exclusively cognitive (390).

# 6.2 EYE-STRAIN AND HEADACHE (Project 45) (Wilkins)

(a) Wilkins has shown that certain patterns of stripes are judged unpleasant to look at and give rise to illusions and complaints of tired eyes and headaches. The spatial and temporal parameters of these stimuli are so similar to those of patterns that induce seizures in patients with photosensitive epilepsy as to suggest common mechanisms of induction of the various unpleasant effects. According to a theory of visual discomfort recently proposed, the illusions are generated in the visual cortex. Certain forms of visual stimulation cause large numbers of cells to fire in a temporally-organised pattern, and if this excitation exceeds a critical mass the discharge may spread. How far it spreads depends on the inhibitory mechanisms. Normally the spread is only slight, from cells that are excited by the stimulus to others responsible for the illusions. Sometimes the discharge spreads further and triggers a seizure. The patterns induce illusions to which people who suffer frequent headaches of the migraine kind are particularly susceptible. If their headaches are confined to one side, of the head the illusions tend to be asymmetric, more on one side of the pattern than the other. If, as the theory proposes, susceptibility to the illusions is a reflection of cortical inhibitory processes, these processes may have something to do with headaches (388). The above work has relied on the facility for testing large groups of subjects and continuation of the work has not been possible since the financial restrictions were imposed.

(b) The theory, has implications not only as regards mechanisms of headaches, but also for the design and display of reading material. Some printed texts form a pattern of stripes with parameters sufficiently close to those of epileptogenic patterns as to induce electrographic abnormalities in photosensitive patients and, in others, illusions, "eye strain" and headaches. These findings have implications for the design of textual material and have suggested that the clarity of text might be improved without increasing its cost by means of the previously described simple reading aid that darkens and blurs the lines of text above and below those being read. This device is similar to those invented in the last century to control "glare". The aid reduces the likelihood not only of eye-strain and headaches (386), but also of reading epilepsy (385).

(c) Computer displays have been associated with complaints of visual discomfort, and the theory outlined above might help explain why. Television can induce seizures in patients with light-sensitive epilepsy, particularly when the screen is viewed from close quarters. Computer displays usually combine the flicker of television with the stripes of text. According to the theory, the discomfort would be reduced if the lines of text were spaced further apart, and the screen illuminated at a higher frequency (381).

(d) The illusions are difficult to quantify and so a search is underway for other physiological indices with which discomfort and its precipitants might be associated. As a result of this search there are now findings that might eventually interrelate visual discomfort and the control of eye movements. Collaborative work with Dr. John Findlay at the University of Durham has shown that the patterns that induce illusions decrease the stability with which the eyes can maintain their gaze. The reading aid reduces considerably the number of movements that the eye makes in looking from one letter to another. Evidently the flanking lines of text compromise the control of the eyes. Such control 1s affected by flicker as well as stripes. When the text is intermittently

illuminated by fluorescent light or on a computer screen the eye movements are slightly enlarged and increased in number (383 U). (see Section 3.7.4)

# 6.3 CLINICAL ASPECTS OF VISUAL PSYCHOPHYSICS (New project) (Watt, Wilkins)

# 6.3.1 Amblyopia

Case studies by Watt in collaboration with Drs. R. Hess and J. Pointer of the Physiological Lab. Cambridge University of amblyopes (anisometropia and strabismic) suggest that the only difference between an amblyopic eye and a normal eye is that the former is rather more spatially uncertain than the latter. The results suggest that the amblyopic visual field is somewhat scrambled.

Amblyopia affects about 1 in 7 of the population and varies considerably in degree. It is proposed to devise clinical test charts both to test the hypothesis more widely and to help evaluate treatment. The work is supported in part by the Wellcome Foundation.

### 6.3.2 The grey-level stage in human vision

The initial stages of human vision effect a transformation from a continuous grey-level image to a symbolic representation recording features such as lines and edges along with certain of their properties. An account of how this is achieved has been worked out in detail by Watt in collaboration with Professor Morgan of University College London. This account has the surprising bonus that a whole range of grouping phenomena can be predicted because the output is a structured representation. The grouping may well be of practical importance for tasks like reading, as it appears to have considerable implications for visual processing of stimuli even when they are only 2 arc degrees from the fovea (344).

## 6.3.3 2D - Shape Representation in Vision

The next step up from the grey-level problem is the stage at which the shape and disposition of edge loci is represented. Watt argues that typically, 2D shape discrimination reflects high precision within a structured framework (343). The "edge-map" is segmented at points of contour termination (343; 347 U), points of contour intersection (345), and sharp angles (346 U). The resultant segments are thus, smooth (twice differentiable) and continuous, and are represented by "bump" primitive shapes (343; 350 U).

# 6.3.4 Clinical tests of contrast sensitivity

Prints of gratings with low contrast have been designed by Wilkins for the rapid "forced choice" examination of contrast sensitivity in the clinical setting. The gratings are cheap to reproduce and provide a test that is quick to administer. The test has been used in collaborative studies with Dr Sergio Delia Sala and others at the University of Milan. The studies have shown that a high proportion of patients with diabetes have impaired contrast sensitivity, regardless of retinopathy (88). Clement Clarke International have expressed an interest in publishing both the low contrast gratings and also another version of the test, currently under development, that uses low contrast letters.

# 6.4. VISUAL ATTENTION, MASKING AND CONSCIOUS AWARENESS (Project 42) (Duncan, Gathercole, Marcel)

While many different cognitive systems are dealt with under the general heading of "attention" (94), this section is concerned with the problem of limited capacity processes in vision. There is a strict limit to the amount of information that can be taken up from the visual field at any one time.

### 6.4.1 Directing attention.

Work on the problem of directing attention to the most important stimuli has led Duncan to the following general model (90). To be reported, any visual stimulus most gain access to a "limited capacity system" (LCS) which deals efficiently with only one stimulus at a time. This applies to the report of all stimulus properties: shape, size, brightness, colour, etc. LCS is preceded by a stage of perceptual analysis (the preselective system) which operates in parallel across simultaneous stimuli, and which serves to direct chosen stimili to LCS. To this end, all stimuli in the preselective system are interviewed for properties defining them to be important, and only stimuli possessing such properties pass on to LCS. For example, if the task is to report red letters in a display of letters in different colours, the colour of each stimulus is interviewed in the preselective system, and only red stimuli pass on to LCS.

An interesting implication of Duncan's model is that, in a sense, stimulus properties are known at the preselective stage, but cannot be reported without access to LCS. For example; colour can guide access to LCS, but cannot be reported until such access has occurred. This has been confirmed for both simple stimulus features such as tilt, and complex properties such as shape (95). It has often been claimed that simple stimulus features can be perceived "without attention", but this claim is apparently wrong. More generally, it appears that one should not speak of a single stage at which some aspect of a stimulus is "identified" (95). Stimulus Information is put to many different uses in the nervous system (directing "attention", underlying action and report, producing perceptual grouping, etc). Showing that information is used for one purpose, at a particular stage, does not imply it can be used for others. (The debate over "unconscious recognition" is a special case.)

Work has continued on the problem of which stimulus properties can be used to guide LCS access. While it still appears that quite complex categorizations (eg digit vs letter) can be employed (91), some results previously ascribed to this process seem in fact to reflect physical differences between categories (92). A new project is dealing with variations in the efficiency of selection using a particular property such as colour (95). Selection of target stimuli for entry into LCS is imperfect. In accounting for this, it may be important to take into account factors such as the interaction between preselective processes and later processes of choosing a speeded response.

Theories of why we are limited in our ability to deal with several stimuli at once fall into three broad classes. Object-based theories propose that LCS deals with only one perceptual object at a time. Discrimination-based theories propose a limit on the number of discriminations that can be made. Space-based theories propose a limit on the spatial area from which information can be taken up.

Duncan's object-based theory is at least partly correct (93). Given a brief display, subjects can report two aspects of one object as accurately as they can report either on its own. They cannot, however, report aspects of two different objects.

A further question is whether there really is only one cause for limited capacity phenomena in vision. For example, we might be limited both in the number of objects we can see, and in the number of similar discriminations (e.g. shape discriminations) we can make. It is, of course, vital to know whether the phenomena of visual attention in fact reflect limits of several distinct sorts, work is in progress on this question.

# 6.4.2 The fate of unattended visual material

One technique frequently employed to assess the fate of unattended visual information 1s to look at whether responses to a target located in a multi-element display are influenced by the identity of the nontargets. Findings that the semantic relationship between target and nontargets falls to have any effect on target performance are typically interpreted as reflecting no detection of the nontargets.

Results obtained by Gathercole in a selective attention task in which nontargets are repeated after a delay, however, suggest that nontargets are registered even when they originally had no detectable effect on target performance. Future experimentation will explore this issue further, with the aim of discovering how the visual attention system handles unwanted information.

# 6.4.3 The influence of vision on touch

Marcel has investigated and extended an ignored illusion which bears on sensory integration. Subjects judge whether an index finger held in front of the face is touched by one or two points. Subjects focus on and monitor a visual display some distance beyond, which produces a double image of the finger. This significantly induces one touch to be felt as two. If, in addition, a filter is worn over one eye, delaying the visual signal from that retina, one touch is sometimes felt as two touches at different points in time. Conversely, stereoscopic fusion of two index fingers may result in two touches, one to each finger, being felt as a single touch. It is suggested that phenomenal sensations are experienced via the body image, which is constructed, and dominated by vision (227 U).

# 7. PSYCHOPHYSIOLOGY SECTION

# 7.1 THE DEVELOPMENT OF PORTABLE APPARATUS FOR ASSESSING DETERIORATION IN SKILL (Project 14) (Wilkinson, Houghton) (terminated 31.3.84)

#### 7.1.1 Field assessment of reduced vigilance

The main achievement of this project has been to produce two small, highly portable, battery-powered devices, one of which presents a Choice Serial Reaction Time (RT) test, and the other a test of Unprepared Simple RT (399), using onboard cassettes to store the data. Software has been written to access these data and analyse them on an Apple microcomputer. These tests have proved highly sensitive to situations which reduce wakefulness and hence impair concentration and attention. The instruments are commercially available and over 400 of them have been bought by establishments wishing to measure these effects objectively in both field and laboratory. Their main application has been in assessing the effects of toxic industrial agents, work schedules in industry and the armed services, abnormal states of sleep, and side-effects of clinical drugs. A prototype microprocessor-based version of the Unprepared Simple RT has also been produced (151), weighing only 650g, including battery. As well as presenting the test and storing all RTs digitally, this device analyses the data and displays the results (mean RT and standard deviation) on the spot.

# 7.2 WORKING CONDITIONS: PERFORMANCE AFTER REDUCED AMOUNTS OF SLEEP (Project 15)

# (Wilkinson, Tilley, Ogilvie)

# 7.2.1 Objective definition of sleep onset

The point of onset of sleep is poorly defined physiologically; this is because efforts to do so have relied mainly on subjective evaluation of sleep onset. Ogilvie and Wilkinson (260) have sought to define this change behaviourally by playing faint 15-sec tones to subjects at irregular intervals as they fall asleep; reasonable cooperation in this was ensured by having them remain awake the previous night. Subjects pressed a button to end each tone as long as they were awake enough to do so. Lack of response was taken as a sign of sleep onset, whereupon the associated physiological changes were noted and the subject wakened for the next trial. Sleep onset was more gradual than expected, and was associated with i) an increase in the ratio of thoracic to abdominal respiration amplitude (259) and 11) the appearance of spindles in the EEG. A second experiment related subjective report and release of a 'dead mans hand' to these indices of sleep onset. In a third study the tones were played throughout a night of sleep. Responses to them provided a clear behavioural picture of the degree and cyclic nature of wakefulness during sleep, with little memory of having responded to any tones by morning.

## 7.2.2 Quality or quantity of sleep

Tilley (328) restricted subjects to only 4 hours sleep a night, but varied the EEG content by allowing sleep either in the first (2300-0300 hr) or second (0300-0700 hr) half of the night. As expected there were more EEG slow waves (Stage 4] and 'rapid eye movements' (REM) when sleep was taken in the first half of the night. Nevertheless, performance the day after reduced sleep, though worse than normal, was the same whichever half of the night was slept. Thus the recuperative power of sleep in terms of performance appears to depend more on the amount of sleep than upon its composition in EEG terms.

# 7.2.3 Recovery from loss of sleep

When recovery sleep is allowed following sleep deprivation the amount of slow wave sleep is usually increased in relation to REM. Tilley (325) has shown that this still happens when only the last half of one night is lost, even though this procedure causes much greater loss of REM than of slow wave sleep. Puzzling.

# 7.3 WORKING CONDITIONS: EFFECT OF SINGLE OR COMBINED ENVIRONMENTAL STRESSES

# (Project 16) (Millar, Tilley, Wilkinson)

# 7.3.1 Side-effects of antihistamine drugs

Millar (234) has examined the effectiveness of an additive designed to reduce the drowsiness resulting from a well-known anti-motion-s1ckness pill. Drowsiness was assessed using portable performance tests described elsewhere. The additive was endorsed.

## 7.3.2 Recovery from anaesthesia

Wilkinson, in collaboration with a team from the Hammersmith Hospital (304), used the portable Choice Serial RT test to trace the time course over two postoperative days of the recovery of vigilance and attention following anaesthesia for minor surgery. Different anaesthetic agents were compared on this basis.

# 7.3.3 Retrieval from semantic long-term memory

Tilley examined retrieval in a setting which compared the speed with which words of differing familiarity (in - terms of frequency of use in the language) are categorised. Subjects are presented with a target (e.g. the word "apple") and a category (e.g. fruit) and press a 'yes' or 'no' button rapidly to say whether or not the target falls within the category. Familiar targets are categorised faster than less familiar ones, such as 'mango'. The research confirmed previous findings that the disadvantage of unfamiliar words Is increased when the test is carried out at a low point in the circadian arousal cycle, in this case 0300 (327), and made the further point that when arousal is low the strategy for identifying unfamiliar items as not belonging to the category is changed to one which economises in effort but at the expense of overall efficiency (326).

# 7.4 INDIVIDUAL DIFFERENCES IN RESPONSE TO STRESS; NOISE AND PERFORMANCE (Project 52) (Ryder, Wilkinson)

#### 7.4.1 Noise and Performance

Research on noise effects on performance has generally produced equivocal results. Increments, decrements and no effect on performance in noise have all been reported. One hypothesis considered is that the range of findings could be due to a small group who are 'noise sensitive'. To test this a group of subjects were intensively studied on a battery of performance tests. Moderate level intermittent noise was used in a simulated office environment.

No significant individual differences were found, and there was little consistency in noise effects over repeated testings. This was true even when significant overall noise effects were found, as was the case with the Sternberg memory comparison task. This test showed significant noise, time of day and interaction effects (300 U). The Implications of these results will be considered in more detail in a further study. Other results from the main study include a number of significant time of day effects on performance and interactions of noise with time of day.

# 7.5 THE PHYSIOLOGICAL CORRELATES OF PERFORMANCE UNDER STRESS: EVENT-RELATED CHANGES IN THE BRAIN AS CORRELATES OF ATTENTION (Project 17) (Allison, Wilkinson)

7.5.1 Endogenous event-related potentials (ERP) in the EEG - specific or nonspecific?

Do ERPs reflect primarily the activity of specific cognitive mechanisms in the brain, or are they mainly the expression of changes in nonspecific background activation, in response to varying attentional states associated with cognitive activity? Wilkinson and Allison have carried out three experiments (396; 397a) to examine these potentials in a setting of unprepared reaction time, either one- or two-choice (the cognitive variable), and under conditions of normal sleep or 30-hr sleep deprivation (the variable thought likely to influence the level of nonspecific activation). Loss of sleep reduced the amplitude of the components concerned, suggesting that ERPs do indeed respond to nonspecific factors; this may account at least partly for their changes in association with cognitive behaviour. Further analysis will show whether they also respond to choice in terms of amplitude or latency.

### 7.5.2 Energy Conservation (Batten, Wilkinson)

In assessing the efficiency with which the energy fed into a house achieves given levels of temperature, ventilation, and dryness, much is known of the contribution of physical variables such as building parameters and environmental influences. Much less is known about the Influence of human behaviour, particularly in the

use of the heating controls, ventilation and doors and their effect on this energy equation, and also the occupant's comfort requirements for both temperature and ventilation.

This project is making a preliminary enquiry into the influence of such behavioural variables. More specifically, we have recorded energy (gas + electricity) consumption and internal temperatures, and monitored a variety of behavioural parameters quarter-hourly over 2 separate weeks In 8 virtually identical gas-centrally-heated terraced houses. The behavioural aspects include activity, clothing, comfort and discomfort, and control of heating, doors, and windows.

The very large amount of data collected is being analysed to discover how particular forms of behaviour and control strategies influence the amount of energy consumed in relation to the temperatures and ventilation found. From a more theoretical point of view, comfort votes are being analysed in relation to temperature, clothing and metabolic rate (inferred from the activity data) to determine whether Fanger's general function intended to predict conditions of ideal comfort hold good in this longitudinal study under actual residential conditions.

#### 7.6 CLINICAL PSYCHOPHYSIOLOGY (Project 47) (Ryder)

### 7.6.1 Computed Axial Tomography (CAT) in schizophrenia

The advent of computed axial tomography (CAT) allows non-invasive measurement of neuroanatomical structures. Recent research reporting increased incidence of ventricular enlargement and of anomalies in neuroasymmetry in schizophrenic patients has raised considerable interest -in the potential use of the CAT technique in psychiatric settings. However the validity and utility of measures derived from CAT scanning remain equivocal.

Preliminary findings in the area suggest that the CAT technique may refine our conceptualization of schizophrenia In terms of aetiology, diagnosis, prognosis and treatment. Ventricular enlargement, which appears to be related to negative symptomatology and poor prognosis, may indicate a distinct clinical subgroup. Research on neuroanatomical asymmetry using CAT scanning offers a new method for investigating the relationship between structural and functional asymmetry. Studies in this area are put in context and implications for future research are considered by Ryder in two review papers (297 U; 298 U).

# 7.7 THE EFFECTS OF NOISE AND SHIFTWORK ON SLEEP (Project 30) (Campbell, Tilley, Wilkinson) 7.7.1 Effects of traffic noise on sleep in the home

Wilkinson and Campbell (71; 391; .398) have reported the main results of this long-term study of the sleep over 5 weeks of 12 people who live on urban arterial roads carrying very heavy traffic at night. Installing double glazing in the bedroom improved the subjectively reported quality of sleep and also performance the next morning. Although many EEG measures were unaffected, low frequency activity (EEG Stage 4), thought to reflect deep sleep, was increased by the sound attenuation. Significant, though small, cardiovascular changes were also noted (397). More recent work has emphasised individual differences in susceptibility to noiseinduced disturbance of sleep. This literature has been reviewed (392), and each subject's records have been analysed individually (393) as follows: The EEG was scored visually for signs of arousal following noise peaks. These were compared, as a control, with similar measurements made at random during the same night. Significantly greater disturbance of sleep by the real noise peaks was demonstrated in two of the people studied. Most of the other ten showed little effect. A similar analysis based on heart rate showed no reliable effect of noise peaks on any of the subjects (394). Overall we conclude that in the population as a whole traffic noise may have a tonic effect of preventing sleep from reaching its normal depth. In a few people, however, there may be an acute effect in which individual peaks can repeatedly cause arousal to a greater or lesser degree. The health of these people may well be at risk if circumstances compel them to live in such noisy surroundings.

# 7.7.2 Shiftwork

A final report (330) has been published by Tilley and Wilkinson on the large scale project funded by the CEC to examine how far daytime sleep on the night shift is degraded as compared with normal night-time sleep. Considerable impairment was found, suggesting progressive sleep deprivation during a week on the night shift, a conclusion reinforced by a steady decline in performance on portable vigilance tests during the week on 'nights' as compared with dayshift weeks. The techniques of measurement developed appear sufficiently rigorous to support a comparative examination of some shift systems in current use in search of those least prejudicial to sleep.

# **PUBLICATIONS LIST**

1. AARTS, J.H.P., BINNIE, CD., SMIT, A.M., S WILKINS, A.J. (1982) Performance testing during epileptiform EEG activity. British Journal of Clinical Practice, Symposium Supplement, 18, 78-80. T.A. Belts, R.J. Hoppener and V. Petersen (eds.).

2. AARTS, J.H.P., BINNIE, CD., SMIT, A.M., 8 WILKINS, A.J. (1984) Selective cognitive impairment during focal and" generalized epileptiform EEG activity. Brain, 107, 293-308.

3. ANDERSON, J.A., & HINTON, G.E. (1981) Models of information processing in the Drain. Tn: Parallel Models of Associative Memory. G.E. Hinton and J.A. Anderson (eds.), Hillsdale, N.J.: Lawrence Erlbaum Associates, pp. 9-48.

4. BADDELEY, A.D. (1982a) Implications of neuropsychological evidence for theories of normal memory.Philosophical Transactions of the Royal Society London B, 298, 59-771

5. BADDELEY, A.D. (1982b) Domains of recollection. Psychological Review, 89, 708-729.

6. BADDELEY, A.D. (1982c) Reading and working memory. Bulletin of the British Psychological Society, 35, 414-417.

7. BADDELEY, A.D. (1983a) The working party on postgraduate education. Bulletin of the British Psychological Society, 36, 9-12.

8. \* BADDELEY, A.D. (1983b) Working memory. Philosophical Transactions of the Royal Society London B, 302, 311-324.

9. BADDELEY, A.D. (1984a) The fractionation of human memory. Psychological Medicine, 14, 259-264.

10. BADDELEY, A.D. (1984b) Neuropsychological evidence and the semantic/episodic distinction: Commentary on Tulving. Behavioral and Brain Sciences, 7, 238-239.

11. BADDELEY, A.D. (1984c) Memory theory and memory therapy. In: Clinical Management of Memory Problems. B.A. Wilson and N. Moffat (eds.), Croom Helm, pp. 5-27.

12. BADDELEY, A.D. (1984d) Reading and working memory. SET Research Information for Teachers, 1, Item 11.

BADDELEY, A.D. (1984e) Is psychology making progress? Thornfield Journal, University College Dublin, pp.
 8-21.

14. BADDELEY, A.D. Human memory. In: Oxford Companion to the Mind. R.L. Gregory (ed.), Oxford: Oxford University Press, (in press).

15. BADDELEY, A.D. Psychologie cognitive de la vie quotIdlenne. Bulletin de Psychologie, (in press).

16. BADDELEY, A.D. Reading and working memory. Visible Language. (in press).

17. 8AD0ELEY, A.D. Memory. In: Social Science Encyclopaedia. A. Kuper and J. Kuoer (eds.), Routledge and Kegan Paul, (in press).

18. BADDELEY, A.D. Working Memory. To be published by Oxford University Press.

19. BADDELEY, A.O., A IDZIKOWSKI. C. Anxiety, manual dexterity and diver performance. Ergonomics, (in press).

20. BADDELEY, A.D., & LEWIS, V. (1984) When does rapid presentation enhance digit span? Bulletin of the Psychonomic Society, 22, 403-405.

21. BADDELEY, A.D., LEWIS, V., ELDRIDGE, M., & THOMSON, N. (1984) Attention and retrieval from long-term memory. Journal of Experimental Psychology: General, 113, 518-540.

22. BADDELEY, A.O., LEWIS, V., i VALLAR, G. (1984) Exploring the articulatory loop. Quarterly Journal of Experimental Psychology, 36A, 281-289.

23. BADDELEY, A.D., LOGIE, R.H., NIMMO-SMITH, I., & BRERETON, N. Components of fluent reading. Journal of Memory and Language, (in press).

24. BADDELEY, A.D., SUNDERLAND, A., & HARRIS, J. (1982) How well do laboratory-based psychological tests predict patients' performance outside the -laboratory. In: Alzheimer's Olsease: A Report of Progress (Aging, Vol. 19). S. Corkin, K.L. Davis, J.H. Growden, E. lisdln and R.J. Wurtman (eds.). New York: Raven Press, pp. 141-148.

25. BADDELEY, A.D., & WILKINS, A.J. (1984) Taking memory out of the laboratory. In: Everyday Memory, Actions and AbsentmIndedness. J.E. Harris and P.E. Morris (eds.). London: Academic Press, pp. 1-17.

26. BADDELEY. A.D., & WILSON, 8. Phonological coding and short-term memory in patients without speech. Journal of Memory and Language, (in press).

27. BADDELEY, A.D., & WILSON, B. Amnesia, autobiographical memory and confabulation. In:

Autobiographical Memory. D. Rubin (ed.), Cambridge University Press, (in press).

28. BADDELEY, A.D., & WOODHEAD, M.M. (1982) Depth of processing, context, and face recognition. Canadian Journal of Psychology, 36, 148-164.

 29. BADDELEY, A.D., & WOODHEAD, M.M. (1983) Improving face recognition ability. In: Evaluating Witness Evidence. S.M.A. Lloyd-Bostock and B.R. Clifford (eds.), London: John Wiley & Sons Ltd., pp. 125-136.
 30. BARNARD, P.J. Experiments on learning interactive dialogues: Problems and prospects. In: Man-Machine Interaction, Proceedings of the 16th Joint IBM/University of Newcastle Seminar, University of Newcastle upon Tyne. M.J. Elphick (ed.), (in press).

31. BARNARD, P.J. Applying the products of research on interactive dialogues. In: Man-Machine Interaction, Proceedings of the 16th Joint IBM/University of Newcastle Seminar, University of Newcastle upon Tyne. M.J. Elphlck (ed.), (in press).

32. \* BARNARD, P.J. Interacting cognitive subsystems: A psycholinguistic approach to short-term memory. In: Progress in the Psychology of Language, Vol. 2. A. Ellis (ed.), London: Lawrence Erlbaum Associates, (in press).

33. BARNARD, P.J. Cognitive resources and the learning of human computer-dialogues. (Manuscript in preparation).

34. BARNARD, P.J., & HAMMOND, N.V. (1982a) Usability and its multiple determination for the occasional user of interactive systems. In: Pathways to the Information Society (Proceedings of the Sixth International Conference on Computer Communication, London). M.B. Williams (ed.), Amsterdam: North Holland Publishing Company, pp. 543-548.

35. BARNARD, P.J., & HAMMOND, N.V. (1982b) Cognitive contexts and Interactive communication. IBM Hursley Human Factors Report No. HF-070, Dec. 19B2.

36. BARNARD, P.J., HAMMOND, N.V., MACLEAN, A., & MORTON, J. (1982a) Learning and remembering interactive commands. In: Proceedings of the Human Factors in Computer Systems, Galthersburg, Maryland, PP. 2-7

 BARNARD, P.J., HAMMOND, N.V., MACLEAN, A., & MORTON, J. (1982b) Learning and remembering interactive commands in a text-editing task. Behaviour and Information Technology, 1, 347-358.
 BARNARD, P.J., MACLEAN, A., & HAMMOND, N.V. (1984) User representations of ordered sequences of command operations. In: INTERACT '84 First IFIP Conference on 'Human Computer Interaction'. London: International Federation for Information Processing, IEE, Vol. 1, pp. 434-438.

39. BEKERIAN, D.A. (1983) The evidence of your eyes. Science Now, 2, 554-555.

40. BEKERIAN, D.A. (1984) The learned helplessness hypothesis: A framework in disguise. Current Psychological Research and Reviews, 3\_. 19-37.

41. BEKERIAN, D.A. Similarity of learning environments and retroactive inhibition. American Journal of Psychology, (in press).

42. BEKERIAN, D.A. Retrieving personal memories. (Paper submitted).

43. BEKERIAN, O.A., & BADDELEY, A.D. (1981) Saturation advertising: Is repetition enough? In: Health
Education and the Media (Proceedings of the International Conference, March 1981, University of Strathclyde).
D.S. Leathar, G.B. Hastings and J.K. Davies (eds.), Pergamon Press Limited, pp. 455-464.

44. \* BEKERIAN, D.A., & BOWERS, J.M. (1983) Eyewitness testimony: Were we misled? Journal of Experimental Psychology: Learning, Memory and Cognition, 9, 139-145.

45. BEKERIAN, D.A., 4 BOWERS, J.M. How to mislead eyewitnesses when intending not to. In: Proceedings of the BPS Conference of Psychology and Law, Swansea, July 1982.

46. BEKERIAN, D.A., & BOWERS, J.M. Biasing the retrieval of accurate memories. British Journal of Psychology,

(in press).

47. BEKERIAN, D.A., A CONWAY, M.A. Vivid memories for personally significant events. (Manuscript in preparation).

48. BEKERIAN, D.A,, CONWAY, M.A., & MINGAY, D.J. Imagery and eyewitness testimony. Paper to be given at 2nd International Imagery Conference, Swansea; 1985, (In press).

49. BEKERIAN. D.A., & DENNETT, J.L. Oral vs. written recall: Is there a difference? (Manuscript in preparation).50. BEKERIAN. D.A: & MINGAY, D.J. Giving people second chances. (Paper submitted).

51. BEKERIAN, D.A., & ROLFE, J. The eyewitness as an information source. In: New Directions in Safety, (in press).

52. BINNIE, CD., DARBY, C.E., DE KORTE, R.A., & WILKINS, A.J. (1981) Interhemispheric differences in photosensitivity thresholds. In: Advances in Epileptology: XIIth Epilepsy International Symposium. M. Dam, L. Gram and J.K. Penry (eds.). New York: Raven Press, pp. 403-411.

53. BINNIE, CO., DE KORTE, R.A., DARBY, C.E., VAN EGMOND, P., WILKINS, A.J., & VELDHUIZEN, R. (1981) Effects of ambient lighting on photosensitivity and television epilepsy. In: Advances In Epileptology: XIIth Epilepsy International Symposium. M. Dam, L.. Gram and J.K. Penry (eds.), New York: Raven Press, pp. 269-273.

54. BINNIE, CD., FINDLAY, J., & WILKINS, A.J. Mechanisms of eplleptogenesis in photosensitive epilepsy implied by the effects of moving patterns. Journal of Electroencephalography and Clinical Neurophysiology, (in press).

55. BINNIE, CD., WILKINS, A.J., & DE KORTE, R.A. (1981) Interhemispheric differences in photosensitive epilepsy. II. Intermittent photic stimulation. Electroencephalography and Clinical Neurophysiology, 52, 469-472.

56. BLACK, A., FREEMAN, P., & JOHNSON-LAIRD, P.N. Plausibility and the comprehension of text. (Manuscript submitted).

57. BOWERS, J.M., & BEKERIAN, D.A. (1984) When will postevent information distort eyewitness testimony? Journal of Applied Psychology, 69, 466-472.

58. BROWN, I.D. (1982a) Measurement of. mental effort: Some theoretical and practical issues. In: Energy and Effort. G.A. Harrison (ed.), London: Taylor 4 Francia, pp. Z/-3/.

59. BROWN, I.D. (1982b) Driving fatigue. Endeavour, New Series, 6, 83-90.

60. BROWN, I.D. (1982c) What is human factors? In: Proceedings of Human Factors Symposium, 18-19 May 1982, Heathrow, London. Harlow: ITT Europe Human Factors Research Group, pp. 1-19.

61. BROWN, I.D. (1983) Parameters of operator adaptability to call-traffic fluctuations in public telephone switchrooms: The essential Ingredient in system design. In: Proceedings of the 10th International Symposium on Human factors in Telecommunications, Helsinki, Finland, 6.-1U June 1983, Helsinki : Posts and Telecommunications of Finland, pp. 213-220.

62. BROWN, I.D. (1984a) Ergonomics and technological change. In: Proceedings of the 21st Annual Conference of the Ergonomics "Society of Australia and New Zealand, Sydney, N.S.W.. "28-30^ November 1984.
63. BROWN, I.D. (1984b) Highway design and road users' perception of hazard. In: Proceedings of the 21st

Annual Conference of the Ergonomics Society of Australia and New Zealand, Sydney, N.S.W. 28-30th November 1984.

64. BROWN, I.D. (1985) Prospects for improving road safety. Ergonomics Society Lecture paper to be presented at the University BT Nottingham, 29th March 1985.

65. BROWN, I.D., & COPEMAN, A.K. (1981) An Investigation of drivers' attitudes and behaviour in relation to road traffic offences. Final Report on Transport and Road Research Laboratory Contract No. CON/6142/37.
66. BROWN, I.D., O'BRIEN, D., & WILSON, P. (eds.) (1983) Human Factors and Information Technology. London: National tlectronlcs Council.

67. BROWN, I.D., WASTELL, D.G., & COPEMAN, A.K. (1982) A

psychophysiological investigation of system efficiency in public telephone switchrooms. Ergonomics, 25, 1013-1040.

68. BROWN, I.D., WASTELL, D.G., TREDRE, B., COPEMAN, A.K., 8 COLLINS, J. (1981) The human factor: A mix of quality, efficiency. Telephony, 200, 20-22.

69. BUXTON, H. (1983a) Auditory lateralization: An effect of rhythm. 8rain and Language. 18. 249-258.

70. BUXTON, H. (1983b) Temporal predictability in the perception of English speech. In: Prosody: Models and Measurements. A. Cutler and D.R. Ladd (eds.), Heidelberg: SprInger-Verlag, pp. 111-121.

71. CAMPBELL, K. (1981) Principles of automatic pattern recognition of human sleep. In: Sleep 1980. W.P. Koella (ed.), (Proceedings of the Fifth European Congress of Sleep Research Amsterdam, 1980), Basel: Karger, pp. 448-451.

72. CLARE, J.N., & YOUNG, R.M. (1984) A review of knowledge elicitation methods. Report on LOKI: Esprit Project 106.

73. COLBOURN, C.J., BROWN, I.D., & COPEMAN, A.K. (1981) Differences In perceived seriousness of overt and covert traffic offenses: Some iinpl 1catioii9 for the effectiveness of legal sanctions. Law and Human Behavior, 5, 219-230.

74. CULTHEART, M., & PATTERSON, K. The assessment of acquired disorders of reading. nil Aphasia. J. Axbury, R. Whurr, M. Wyke and M. Coltheart (eds.), London: Butterworths, (in press).

75. CONRAD, R., & WEISKRANTZ, B.C. (1981) On the cognitive ability of deaf children with deaf parents. American Annals of the Deaf, 126, 995-1003.

76. CONWAY, M.A., & BEKERIAN, D.A. Personal and semantic memory access. (Manuscript submitted).

77. CONWAY, M.A., & BEKERIAN, D.A. Schematic representations of emotions. (Manuscript in preparation).

78. CONWAY, M.A., & NORRIS, D. Cognitive factors affecting keyword selection. Paper to be given to the 11th International Symposium on Human Factors in Telecommunications, Renes, France, September 1985.

79. COTTER, C. (1983) Inference making processes in reading. Unpublished PhD Thesis, University of Cambridge. 1983.

80. COTTER, C. (1984) Inferring indirect objects in sentences: Some implications for the semantics of verbs. Language and Speech, 27, 25-45.

81. CRAIG, A., WILKINSON, R.T., & COLQUHOUN, W.P. (1981) Diurnal variation m vigilance efficiency. Ergonomics, 24, 641-651.

82. CUTLER, A. (1983) Lexical compexity and sentence processing. In: The Process of Language

Understanding. G.B. Flores d'Arcais and R.J. Jarvella (eds.), Wiley & Sons, pp. 43-79.

83. CUTLER, A. Performance measures of lexical complexity. In: Meaning and the Lexicon. P. Seuren and P. Bosch (eds.), Dordrecht: Foris, (in press).

84. CUTLER, A. Forbear is a homophone: Lexical stress does not constrain lexical access. (Manuscript submitted).

85. CUTLER, A., & CLIFTON, C. (Jr.) (1984) The use of prosodic information in word recognition. In: Attention and Performance X. H. Bouma and D.G. Bouwhuis (eds.), Hillsdale. N.J.: Lawrence Tribaum Associates, pp. 183-196.

86. CUTLER, A., HAWKINS, J.A., & GILL1GAN, G. The suffixing preference: A processing explanation. Linguistics, (in press).

87. CUTLER, A., MEHLER, J., NORRIS, D., & SEGUI, J. (1983) A language-specific comprehension strategy. Nature, 304, 159-160.

88. DELLA SALA, S., BERTON1. G., SOMAZZI. L., STUBBE, F., & WILKINS A.J. Impaired contrast sensitivity in diabetic patients with and without retinopathy: A new technique for rapid assessment. British Journal of Ophthalmology. (in press).

 BUNCAN, J. (1981a) Does cognitive psychology need "New direction"? (Review of Cognitive Psychology: New Directions, G. Claxton (ed.), London: Routledge and Kegan Paul, 1980). Contemporary Psychology, 26.
 472-473.

90. DUNCAN, J. (1981b) Directing attention in the 'visual field. Perception and Psychophysics, 30, 90-93.

DUNCAN, J. (1983a) Perceptual selection based on alphanumeric class: Evidence from partial reports.
 Perception and Psychophysics. 33. 533-547.

92. DUNCAN, J. (1983b) Category effects in visual search: A failure to replicate the "oh-zero" phenomemon. Perception and Psychophysics, 34, 221-232.

93. \* DUNCAN, J. (1984) Selective attention and the organization of visual information. Journal of Experimental Psychology: General, 113, 501-517.

94. DUNCAN, J. Attention. In: The Social Science Encyclopaedia. A. Kuper and J. Kuper (eds.), London: Routledge and Kegan Paul, (in press).

95. DUNCAN, J. Visual search and visual attention. In: Attention and Performance XI M.I. Posner and O. Marin (eds.), Hillsdale, N.J.: Lawrence Erlbaum Associates, (in press).

96. EDWORTHY, J. Melodic contour and musical structure. In: Musical Structure and Cognition. P. Howell, I. Cross and R. West (eds.). Academic Press, fin press).

97. EDWORTHY, J. Interval and contour in melody processing. In: Music Perception (Special Issue). W.R. Crozler and A.J. Chapman (eds.), (in press).

 98. ELDRIDGE, M.A., NIMMO-SMITH, I., WING, A.M., & TOTTY, R.N. (1984) The variability of selected features in cursive handwriting: Categorical measures. Journal of the Forensic Science Society, 24, 179-219.
 99. ELDRIDGE, M.A., NIMMO-SMITH, I., WING, A.M., & TOTTY, R.N. The dependence between selected

categorical measures of cursive handwriting. Journal of the Forensic Science Society, (in press).

100. EVETT, L., PATTERSON, K., MORTON, J., & KAY, J. Effects of bias on nonword pronunciation. .(Manuscript in preparation).

101. FISCHHOFF, B. (1983a) Predicting frames. Journal of Experimental Psychology: Learning, Memory and Cognition, 9, 103-IIb.

102. FISCHHOFF, B. (1983b) Strategic policy preferences: A behavioral decision theory perspective. Journal of Soda! Issues, 39, 133-160.

103. FISCHHOFF, B., & BEYTH-MAROM, R. (1983) Hypothesis evaluation from a Bayeslan perspective.

Psychological Review, 90. 239-260.

104. FORSTER, P.M. (1982) A note on the masking of pictures. Perception. U\_, 319-324.

105. FORSTER, P.M. (1983) An Investigation into the representation involved in visual masking. Perception, 12, 347-353.

106. FRASER, C, I WING, A. (1981) A case study of reaching by a user of a manually-operated artificial hand. Prosthetics and Orthotics International, \_5\_, 151-156.

107. FRIEDMAN, W.J., & WILKINS A.J. Scale effects in memory for the time of events. Memory and Cognition, (in press).

108. GAILLARD, A.W.K. The CNV as an Index of response preparation. In: Proceedings of the Seventh Conference on Event-Related Potentials of the Brain. W.C. McCallum led.), Electroencephalography and" Ciin'cal Seu'-cphyslsiogy Supplement, (in press).

109. van GALEN, G., V WING, A.M. The sequencing of movements. In: The Psychology of Human Movement. M.M. Smyth and A.M. Wing (eds.) New York: Academic Press, (in press).

110. GAMMACK, J.G., & YOUNG, R.M. (1984) Psychological techniques for knowledge elicitation. In: ECAI-84: Advances in Artificial Intelligence. T. O'Shea (ed.), Elsevier Science Publishers BV (North-Holland), pp. 456-457.

111. GAMMACK, J.G., & YOUNG, R.M. (1985) Psychological techniques for eliciting expert knowledge. In:
Research and Development in Expert Systems. M.A. Bramer (ed.), Cambridge University Press, pp. 105-112.
112. GERVER, D., LONGLEY, P., LONG. J.B., & LAMBERT, S. (1984) Selecting trainee conference interpreters: A preliminary study. Journal of Occupational Psychology. 57. 17-31.

113. GIPSON, P. (1984) A study of the long-term priming of auditory word recognition. Unpublished PhD Thesis, University of Cambridge.

114. GLASBERG, B.R., MOORE, B.C.J., & LUTFI, R.A. (1982) Off-frequency listening and masker uncertainty. Journal of the Acoustical Society of America, 72, 273-275.

115. GLASBERG, B.R., MOORE, B.C.J., & NIMMO-SMITH. I. (1984) Comparison of auditory filter shapes derived with three different maskers. Journal of the Acoustical Society of America, 75, 536-544.

116. GLASBERG, B.R., MOORE, B.C.J., PATTERSON, R.D.. & NIMMO-SMITH, I. (1984) Dynamic range and asymmetry of the auditory filter. Journal of the Acoustical Society of America, 76, 419-427.

117. GREEN, T.R.G. Computer languages: Everything you always wanted to know but no-one can tell you. In:
Proceedings of the First Madnter Conference on Man-Computer Interaction. East Berlin, 1984, (in press).
118. GREEN, T.R.G., & NIMMO-SMITH, I. (1962) 'Outcome-counting' -Significance tests from incomplete

predictions of order. British Journal of Psychology, 73, 41-49.

119. GRUDIN, J. (1983a) Errors patterns in novice and skilled transcription typing. In: Cognitive Aspects of Skilled Typewriting. W.E. Cooper (ed.), New York: Springer-Verlag, pp. 121-143.

120. GRUDIN, J. (1983b) Non-h1erarchic specification of components in transcription typewriting. Acta Psychologica, 54, 249-262.

121. GRUDIN, J. (1984) Identification of skilled typists. Journal of the Forensic Science Society, 24, 127-130. 122. GRUDIN, J., 4 BARNARD, P. (1984a) The role of prior task experience in command name abbreviation. In: INTERACT '84 First IF IP Conference 'on 'Human Computer Interaction'. London: International Federation for Information Processing, IEE, Vol. I, pp. 439-443.

123. GRUDIN, J., & BARNARD, P. (1984b) The cognitive demands of learning and representing command names for text-editing. Human Factors, 26, 407-422.

124. GRUDIN, J., & BARNARD, P. When does abbreviation become a word? And related questions. In: Proceedings of CHI '85 Third Conference on Human Factors in Computer Systems"" San Francisco: ACM, (in press).

125. GRUDIN, J., & MACLEAN, A. (1984) Adapting a psychophysical method to measure performance and preference tradeoffs in human-computer interaction. In : INTERACT '84 First IF IP Conference on 'Human Computer Interaction, London: International Federation for Information Processing, IEE, Vol. 2, pp. 338-342.
126. \* HAMMOND, N.V., & BARNARD, P.J. 'Dialogue design: Characteristics of user knowledge. In: Fundamentals of Human-Computer Interaction. A. Monk (ed.), London: Academic Press, (in press).
127. HAMMOND, N.V., HINTON, G., BARNARD, "P., MACLEAN, A., LONG, J.B., & WHITEFIELD, A. (1984)
Evaluating the Interface of a document processor: A comparison of expert judgement and user observation. In: INTERACT '84 First IFIP Conference on 'Human Computer Interaction'. London: international federation tor

inrormation Processing, IEE, Vol. 2, pp..135-139.

128. HAMMOND, N.V., UORGENSEN, A.J., MACLEAN, A., BARNARD, P.J., & LONG, J.B. (1983) Design practice and interface usability: Evidence from interviews with designers. In: CHI '83 Conference Proceedings: Human Factors in Computing Systems. A. Janda (ed.), Boston: ACM, pp. 40-44.

129. HAMMOND, N.V., MACLEAN, A., HINTON, G., LONG, J.B., BARNARD, P.J., & CLARK, I.A. (1983) Novice use of an interactive graph-plotting system. IBM Hursley Human Factors Report HF.083.

130. HAMMOND, N.V., MORTON, J., BARNARD, P.J., LONG, J.B., & CLARK, I.A. (1984) Characterising user performance in command-driven interactive dialogue. IBM Hursley Human Factors Report, HF.093.

131. HAMMOND, N.V., MORTON, J., MACLEAN, A., & BARNARD, P.J. (1983) Fragments and signposts: Users' models of the system. In: Proceedings of the Tenth International Symposium of Human Factors in Telecommunications. Helsinki, June 1983, pp. 81-88.

132. HARRIS, J.E. (1982) External memory aids. In: Memory Observed: Remembering in Natural Contexts. U. Nelsser (ed.), San Francisco: W.H. Freeman, pp. 337-342.

133. HARRIS. J.E. (1984a) Remembering to do things: A forgotten topic. In: Everyday Memory, Actions and Absent-Mindedness. J.E. Harris and P.E. Morris (eds.), London: Academic Press, pp. 71-92.

134. HARRIS, J.E. (1984b) Methods of improving memory. In: Clinical Management of Memory Problems. B.A.

Wilson and N. Moffat (eds.), Beckenham: croom Helm, pp. 4b-62.

135. HARRIS, J.E., & BARNARD, P.J. (1984) A feasibility study of tools for representing operators' Interactions with naval command and control systems. Scicon Human Factors Report HR-2 under contract NSW 32A/1180 for ARE (Portsdown), pp. 54.

136. HARRIS, J.E., & SUNDERLAND, A. (1981) A brief survey of the management of memory disorders in rehabilitation units in Britain. International Rehabilitation Medicine, 3, 206-209.

137. HARRIS, J.E., & WILKINS, A.J. (1982) Remembering to do things: A theoretical framework and an illustrative experiment. Human Learning, \_1\_, 123-136.

138. HATFIELD, F.M. Visual and phonological factors in acquired dysgraphia. Neuropsychologia, (in press).139. HATFIELD, F.M., S HOWARD, D. Aphasia therapy through the centuries. In: Aphasia. J. Oxbury, R. Whurr, M. Wyke and M. Coltheart (eds.), London: Butterworths, (in press).

140. HATFIELD, F.M., & PATTERSON, K.E. (1983) Phonological spelling. Quarterly Journal of Experimental Psychology, 35A, 45.1-468.

141. HATFIELD, F.M., & PATTERSON, K.E. (1984) Interpretation of spelling disorders in aphasia: Impact on recent developments in cognitive psychology. In: Advances In Neurology, Progress in Aphasiology, Vol. 42. F.C. Rose (ed.), New York: Raven Press, pp. 183-192.

142. HESS, R., POINTER, J., &WATT, R. Phase discrimination Is a space domain task. (Manuscript submitted). 143. HEUER, H., & WING, A.M. Doing two things at once: Process limitations "and" interactions. In: The Psychol pay of Human Movement. M.M. Smyth and A.M. Wing (eds.), New York: Academic Press, (in press). 144. \* HINTON, G.E. (1981a) Implementing semantic networks in parallel hardware. In: Parallel Models of Associative Memory. G.E. Hinton and J.A. Anderson (eds.), Hillsdale, N.J.: Lawrence Erlbaum Associates, pp. 161-187.

145. HINTON, G.E. (1981b) The role of spatial working memory in shape perception. In: Proceedings of the Third Annual Conference of the Cognitive Science Society, University of California, Berkeley.

146. HINTON, G.E. (1981c) Shape representation in parallel systems. In: Proceedings 'of the Seventh International Joint Conference on Artificial Intelligence: Vol 2. University of British Columbia, Vancouver, B.C., Canada, 1981, pp. 1088-1096.

147. HINTON, G.E. (1981d) A parallel computation that assigns canonical object-based frames of reference. In: Proceedings of the Seventh International Joint Conference on Artificial Intelligence: Vol.2. University of British Columbia, Vancouver, B.C., Canada, 1981, pp. 683-685.

148. \* HINTON, G.I., & ANDERSON, J.A. (eds.) (1981) Parallel Models of Associative Memory. Hillsdale, N.J.: Lawrence Erlbaum Associates.

149. HITCH, G.J., & BADDELEY, A.D. (1983) Ulteriores desarrollos en la investigacion sobre memoria en functionamiento. In: Lecturas de Psicologia de la Memorla. M.V. Sebastian (ed.), Madrid: Alianza, pp. 486-528.
150. HOKNE, J.A., ANDERSON, N.R., & WILKINSON, R.T. (1983) The effects of sleep deprivation on signal detection measures of vigilance: Implications for sleep function. Sleep, 6, 347-358.

151. HOUGHTON, D., & WILKINSON, R.T. (1982) Microreaction timer.

152. HOWARD, D., & HATFIELD, F.M. Contemporary approaches to aphasia therapy. Iril Aphasia. J. Oxbury, R.

Whurr, M. Wyke and M. Coltheart (eds.), London: Butterworths, (in press).

153. HOWARD, D., PATTERSON, K., FRANKLIN, S.. MORTON, J.. & ORCHARD-LISLE, V. (1984 Variability and consistency in picture naming by aphasic patients. In: Progress in Aphaslology, Advances In Neurology, Vol. 42. F.C. Rose (ed.), New York: Raven Press, pp. 263-276. Behavior Research Methods and Instrumentation, 14, 455-458.

154. HOWARD, D., PATTERSON, K., FRANKLIN, S., ORCHARD-LISLE, V., & MORTON, J. The facilitation of picture naming in aphasia. Neuropsychologia, (in press).

155. HOWARD, P., PATTERSON, K, FRANKLIN, S., ORCHARD-LISLE, V., & MORTON, J. Treatment of word retrieval deficits in aphasia: A comparison of two therapy methods. (Manuscript submitted).

156. HUMPHREYS, G.W., EVETT, L. J, & TAYLOR, D.E. (1982) Automatic phonological priming In visual word recognition. Memory and Cognition, 10, 576-590.

157. IDZIKOWSKI, C. (1982) Interrupts: An interrupt routine for Apple II PASCAL 1.1. Behavior Research Methods and Instrumentation, 14, 491.

158. IDZIKOWSKI, D., & BADDELEY, A.D. (1983) Waiting in the wings. Apprehension, public speaking and performance. Ergonomics, 26, 575-583. [Also Army Personnel Research Committee, Report 8271 (1982).] 159. IDZIKOWSKI, C, & BADDELEY, A. Reflections on fear and performance. Army Personnel Research Establishment Report, (in press).

160. IDZIKOWSKI, C, & BADDELEY, A. ' Fear and performance in novice parachutists. (Submitted for publication).

161. JOHNSON-LAIRD, P.N. (1983a) Which comes first: Logic or rationality? A commentary on H.E. Kyburg's paper: Rational Believ. Behavioral and Brain Sciences, 6, 252-253.

162. JOHNSON-LAIRD, P.N. (1983b) Review - Ekberg, P.H.: A model of natural reasoning with syllogisms. Goteborg Psychological Reports, 1981, 11, No. 4, ASSN 0348-2901. Scandinavian Journal of Psychology, 24, 157-158. :

163. JOHNSON-LAIRD, P.N. (1983c) Images, models and propositions. Ricerche di Psicologia, 25, 37-71.164. JOHNSON-LAIRD, P.N. (1983d) A computational analysis of consciousness. Cognition and Brain Theory, 6, 499-508.

165. JOHNSON-LAIRD, P.N. |1983e) Thinking as a skill. In: Thinking and Reasoning. J.St.B.T. Evans (ed.), London: Routledge and Kegan Paul, pp. 164-196.

166. JOHNSON-LAIRD, P.N. (1984a) Deductive thinking: "How we reason. In: Handbook of Cognitive Neuroscience. M.S. Gazzaniga (ed.), New York: Plenum Publishing Corp., pp. 249-274.

167. JOHNSON-LAIRD, P.N. (1984b) Semantic primitives or meaning postulates: Mental models of propositional representations? In: Computational Models of Natural Language Processing. B.G. Bara and G. Gulda (eds.), Elsevier Science Publishers, B.V., (North-Holland) pp. 227-246.

168. JOHNSON-LAIRD, P.N. (1984c) Psychology and linguistics. In: Psychology and Allied Disciplines. M.H. Bornstein (ed.). Hillsdale, N.J.: Lawrence Erlbaum Associates, (in press).

169. JOHNSON-LAIRD, P.N. (1985) Deductive reasoning ability. In: Human Abilities: An Information-Processing Approach. R. Sternberg (ed.), San Francisco: Freeman, pp. 1/3-194.

170. JOHNSON-LAIRD, P.N. Conditionals and mental models. In: On Conditionals. C. Ferguson, J. Rellly, A. ter Meulen and E.C. Traugott Teds.), Cambridge: Cambridge University Press, (in press).

171. JOHNSON-LAIRD, P.N. Logical thinking: Does it occur in daily life? Can it be taught? In: Thinking and Learning Skills, Vol. 2: Research and Open Questions! S. Chipman, J. Segal and R. Glaser (eds.). Hillsdale, N.J.: Trlbaum, (in press).

172. JOHNSON-LAIRD, P.N. Human and computer reasoning. Trends in NeuroSdences, (in, press).

173. JOHNSON-LAIRD, P.N. Reasoning without logic. In: Reasoning and Discourse Processes. T. Myers (ed.), London: Academic Press, in press).

174. JOHNSON-LAIRD, P.N. The mental representation of the meaning of words. (Manuscript submitted).

175. \* JOHNSON-LAIRD, P.N., & BARA, B.G. (1984a) Syllogistic inference. Cognition, 16, 1-61.

176. JOHNSON-LAIRD, P.N., & BARA, B.G. (1984b) Logical expertise as a cause of error: A reply to Boolos. Cognition. 17, 183-184.

177. JOHNSON-LAIRD, P.N., HERRMANN, D.J., & CHAFFin, R. (1984) Only connections: A critique of semantic networks. Psychological Bulletin, 96, 292-315.

178. JOHNSON-LAIRD, P.N., OAKHILL, J.V., & BULL, D. Children's sylloqistic reasoning. (Manuscript submitted).

179. JORGENSEN, A., BARNARD, P., HAMMOND, N., & CLARK, I. (1983) Naming commands: An analysis of designers' naming behaviour. In: The Psychology of Computer Use. T.R.G. Green, S.J. Payne and G.C. Van der veer (eds.), Lonaon: Academic Press, pp. 69-88.

180. KASTELEIJN-NOLST TRENITE, D.G.A., BINNIE, CO., DE KORTE, R.A., OVERWEG, J., PETERS. A.C.B., & WILKINS, A.J. (1982) Correlative electrophysiological and clinical studies In photosensitive epilepsy. British Journal of Clinical Practice, Symposium Supplement, 18, 81-83. T.A. Belts. R.J. Hoppener and V. Petersen (eds.)

181. KAY, J. (1983) Psychological mechanisms involved in oral reading of single words. Unpublished PhD Thesis, University of Cambridge, 1983.

182. \* KAY, J., & MARCEL, A.J. (1981) One process, not two, in reading aloud: Lexical analogies do the work of non-lexical rules. Quarterly Journal of Experimental Psychology, 33A, 397-413.

183. KAY, J., & PATTERSON, K. Routes to meaning in surface dyslexia. In: Surface Dyslexia. K. Patterson, J.C. Marshall and M. Coltheart (eds.), London: Erlbaum, (in press).

184. KEMPLEY, S.T., & MORTON, J. (1982) The effects of priming with regularly and irregularly related words in auditory word recognition. British Journal of Psychology, 73, 441-454.

185. LEE, D.N., LOUGH, F., & LOUGH, S. (1984) Activating the perceptuo-motor system in hemiparesis. Journal of Physiology, 349, p. 28.

186. LEVEY, A.B. (1984) Personality factors in human conditioning. Activitas Nervosa Superior, 26, 1-8.

187. LEVEY, A.B., BEYTS, J., FRCKA, G., & MARTIN, I.D. (1983) The influence of psychoticism and extraversion on classical eyelid conditioning using a para-orbital shock UCS. Personality and Individual Differences, 4, 275-283.

188. LEVEY, A.B., FRCKA, G., BEYTS, J., & MARTIN, I.D. (1983) The role of awareness in human conditioning.

Pavlovian Journal of Biological Science, 18, 69-76.

189. \* LEVEY, A.B., & MARTIN, I.D. (1983a) Cognitions, evaluations and conditioning: Rules of sequence and rules of consequence. Advances in Behaviour Research and Therapy, 4\_, 181-195.

190. LEVEY, A.B., & MARTIN, I.D. (1983b) Part VII. Reply to comments on "Cognitions, Evaluation and Conditioning". Advances in Behaviour Research and Therapy, 4\_, 219-223.

191. LEVEY, A.B., & MARTIN, I.D. Conditioning, evaluations and cognitions: An axis of Integration. Behaviour Research and Therapy, (in press).

192. LEVEY, A.B., & MARTIN, I.D. Knowledge and control: Associative and cognitive effects in human conditioning. (Manuscript submitted).

193. LEVEY, A.B., MARTIN, I.D., BLIZARD, R., & COBB, M. Extinction failure in classical conditioning as a mechanism of psychosomatic illness. In: . Section Symposium S.IX.I, Physiological Investigations of Psychological Processes in Health an? Psychiatric Diseases, Proceedings of the 7th World Congress 6T Psychiatry, (in press).

194. LEVEY, A.B., MARTIN, I.D., BLIZARD, R., & COBB, M. A psycho-physiological model of psychophysiological disorder. In: ClirIcal and Experimental Neuroosychophysiology. D. Papakostopoulos, S. Butler and I. Martin (eds.), Beckenham: Croom Helm, (in press).

195. LIMBERT, C. (1984) The perception of repeated noise. Unpublished PhD Thesis, University of Cambridge.196. LOGIE, R.H. (1984) Computer selection of verbal research materials. Behavior Research Methods,Instrumentation, and Computers, 16, 59-60.

197. LOGIE, R.H. Sketching on the visuo-spatial scratch pad: Experiments on visuo-spatial processing in working memory. (Manuscript submitted).

198. LOGIE, R.H., & BADDELEY, A.D. (1983a) A trimix saturation dive to 660 metres: 'Studies of cognitive performance, mood and sleep quality. Ergdnomics, 26, 359-374. [Also Royal Naval Personnel Research Committee, Report RNP 2/82 (March 1982).]

199. LOGIE, R.H., & BADDELEY, A.D. (1983b) Simulated deep-sea diving in trimix, oxyhellum and osynitrogen: Studies of cognitive performance, sleep quality and mood. In: Proceedings of the

Ergonomics Society's Conference. K.Coombes (ed.), London: Taylor and Francis, pp. 177-180.

200. LOGIE, R.H., & BADDELEY, A.D. Cognitive performance during simulated deep-sea diving. Ergonomics, (in press).

201. LOGIE, R.H., & EDWORTHY, U. Melodies and the inner ear: A study of musical working memory. (Manuscript in preparation).

202. LONG, J.B., HAMMOND, N.V., BARNARD, N.V., MORTON, J., & CLARK, I.A. (1982) Introducing the interactive computer at work: The users' views. Human Factors Report HF060, IBM (UK) Laboratories, Hursley, July 1982.

203. LONG, J.B., HAMMOND, N.V., BARNARD, P.J., MORTON, J., & CLARK, I.A. (1983) Introducing the interactive computer at work: The users' views. Behaviour and Information Technology. 2, 39-106.
204. LONG, J.B., NIMMO-SMITH, I., & WHITEFIELO, A. (1983) Skilled typing: A characterization based on the distribution times between responses. In: Cognitive Aspects of Skilled Typing. W.E. Cooper (ed,), New York:

Springer-Verlag, pp. 145-195.

205. LONG, J., WHITEFIELD, A., & DENNETT, J. (1984) The effect of display format on the direct entry of numerical Information by pointing. Human Factors, 26, 3-17.

206. LOUGH, S., A LOUGH, F. Recovery of arm function after stroke: The efficacy of physiotherapy. (Manuscript in preparation).

207. LOUGH, S., WING, A.M., FRASER, C, & JENNER, J.R. (1984) Measurement of recovery of function in the hemiparetic upper limb following stroke: A preliminary report. Human Movement Science, 3, 247-256.

208. LUTFI, R.A., & PATTERSON, R.D. (1982) Combination bands and the measurement of the auditory filter. Journal of the Acoustical Society of America, 71, 421-423.

209. LUTFI, R.A., & PATTERSON, R.D. (1984) On the growth of masking asymmetry with stimulus intensity. Journal of the Acoustical Society of America, 76, 739-745.

210. MACLEAN, A., BARNARD, P., & HAMMOND, N. (1984) Recall as an Indicant of performance in interactive systems. In: INTERACT '84 First IF IP Conference on 'Human-Computer Interaction'. London: International Hederation for Information Processing, IEE, Vol. 2, pp. 15-19.

211. MACLEAN, A., BARNARD, P.J., & WILSON, M. A comparison between performance and preference tradeoffs in a data entry task. (Manuscript to be submitted to the 11th International Symposium on Human Factors in Telecommunications).

212. McKENNA, F.P. (1982) The human factor in driving accidents. An overview of approaches and problems. Ergonomics, 25, 867-877.

213. McKENNA, F.P. (1983a) Accident proneness: A conceptual analysis. Accident Analysis and Prevention, 15, 65-71.

214. McKENNA, F.P. (1983b) Field dependence and personality: A re- examination. Social Behavior and Personality, 11, 51-55.

215. \* McKENNA, F.P. (1984a) Measures of field dependence: Cognitive style or cognitive ability? Journal of Personality and Social Psychology, 47, 593-603.

216. McKENNA, F.P. (1984b) Assimilation and contrast in perceptual Judgements. Quarterly Journal of Experimental Psychology, 36A, 531-548.

217. McKENNA, F.P. Another look at the "New Psychophysics". British Journal of Psychology, (in press).

218. McKENNA, F.P. Do safety measures really work? An examination of risk homeostasis theory. Ergonomics, (in press).

219. McKENNA, F.P. Are we rational or irrational about accident risk? Traffic Education, (in press).

228. McKENNA, F.P. Modifying the Gestalt factor of proximity: Adaptation level theory versus response frequency equalization. (Manuscript submitted).

221. McKENNA, F.P. Questioning the educational implications of one cognitive style. (Manuscript submitted).

222. McKENNA, F.P. The effect of emotional stimuli on selective attention. (Manuscript submitted).

223. \* McKENNA, F.P., DUNCAN, J., & BROWN, I.D. Cognitive ability and safety on the road: A re-examination of individual differences in dichotic listening and search for hidden figures. (Manuscript submitted). 224. \* McLEOD, P., MCLAUGHLIN, C, S NIMMO-SMITH, I. Information encapsulation and automaticity:

Evidence from the visual control of finely timed actions. In: Attention and Performance XI. M.I. Posner and 6. Marin (eds.), Hillsdale, N.J.: Lawrence Erlbaum Associates, (in press).

225. "McLEOD, P., \* POSNER, M.I. (1984) Privileged loops from percept to act. In: Attention and Performance X. H. Bouma and D.G. Bouwhuis (eds.), Hillsdale, N.J.: Lawrence Erlbaum Associates, pp. 55-66.

226. MARCEL, A.J. Cognitive science, dynamic psychology and meaning. In: Emotional and Cognitive Factors In Unconscious Processes. M. Horowitz (ed.), (in press).

227. MARCEL, A.J. A tactile illusion produced by vision. (Manuscript in preparation).

228. MARCEL, A.J., & WILKINS, A.J. Cortical blindness: A problem of visual function or visual consciousness? (Manuscript in preparation).

229. MAKGOLIN, D.I., & MARCEL, A.J. Anomic alexia: Circumlocutory responses in reading and naming. Archives of Neurology, On press).

230. MARGOLIN, D.I., MARCEL, A.J., & CARLSON, N. Common mechanisms in dysnomia and post-semantic surface dyslexia: Processing deficits and selective attention. In: Surface Dyslexia. K.E. Patterson, J.C. Marshall and M. Coltheart [eds.I, London: Lawrence Erlbaum Associates, (in press).

231. MARGOLIN, D.I., & WING, A.M-. (1983) Agraphia and mlcrographla: Clinical manifestations of motor programming and performance disorders. Acta Psychologica, 54, 263-283.

232. MARSHALL, J.C. & PATTERSON; K.E. (1983) Semantic paralexia and the wrong hemisphere! A note on Landls, Regard, Graves and Goodglass (1983). Neuropsychologia, 21, 425-427.

233. MELDRUM. B.S., & WILKINS, A.J. (1984) Photosensitive epilepsy in man and the Baboon: Integration of pharmacological and psychophysical evidence. In: Electrophysiology and Epilepsy. P. Schwartzkroln and H.V. Wheal (eds.), London: Academic Press, pp. 51-77.

234. MILLAR, K., & WILKINSON R.T. (1981) The effects upon vigilance and reaction speed of File addition of Ephedrine Hydrochloride to Chlorpheniramine Maleate. European Journal of Clinical

Pharmacology, 20, 351-357.

235. 'MINGAY, D.J., DENNETT, J.L., & BEKERIAN, D.A. Memory for a staged Incident. In: Proceedings of ISASI Conference, (in press). .

236. MORRIS, R.G. (1984) Dementia and the functioning of the articulatory loop system. Cognitive

Neuropsychology, 1, 143-157.

237. MORTON, J. (1981a) Will cognition survive? Cognition, 10, 227-234.

238. MORTON, J. (1981b) The status of information processing models of language. Philosophical Transactions of the Royal Society London B, 295, 387-396

239. MORTON, J. (1983) La Lexique Interne (French transcript). La

Recherche, 143, April, 474-481.

240. MORTON, J. (1984) Brain-based and non-brain-based models of language. In: Biological Perspectives in Language. D. Caplan, A.R. Lecours and A. Smith [eds.), Cambridge, Mass.: M.I.T. Press, pp. 40-64.
241. MORTON, J., \* BEKERIAN, D.A. (1984) The episodic/semantic distinction: Something worth arguing about. Behavioral and Brain Sciences, 7, 247-248.

242. MORTON, J., HAMMERSLEY, R.H., & BEKERIAN, D.A. Headed records: A model of memory and its failures.

Cognition, (in press).

243. MORTON, J., PATTERSON, K., NIMMO-SMITH, I., KAY, J., & EVETT, L. The modified standard model for the conversion of orthography to phonology. (Manuscript in preparation).

244. N1CKERSON, R.S., BADDELEY, A.D., & FREEMAN, B. Are people's estimates of what other people know Influenced by what they themselves know? (Submitted for publication)

245. NORMAN, D.A., & SHALLICE. T. Attention to action: Willed and automatic control of behavior. In: Consciousness and Self Regulation: Advances in Research, Vol. IV. R.J Davidson, G.E. Schwartz and D. Shapiro [eds.], New York: Plenum Press, (in press).

240. NORRIS, D.G. (1984a) A computer-based programmable tachistoscope for nonprogrammers. Behavior Research Methods, Instruments, and Computers, 16, 25-27.

247. NORRIS, D.G. (1984b) The effects of frequency, repetition and stimulus quality in visual word recognition. Quarterly Journal of Experimental Psychology, 36A, 507-518.

2411. NORRIS. D.G. (1984c) The misprinting effect: Evidence of an orthographic check in the lexical decision task. Memory and Cognition, 12, 470-476.

249. NORRIS, D.G. Semantic and syntactic processes in comprehension. In: Linguistic Dynamics, Vol. I. T.H. Balmer (ed.), (in press).

250. NORRIS, D.G. Comprehension strategies and lexical priming. Language and Speech, (in press).

251. NORRIS, D.G. Random factors and random hypothesis. (Manuscript submitted).

252. .NORRIS, D.C.. Word recognition: Lowest effects without priming. (Manuscript submitted).

253. NORRIS, D.G., & BROWN, G. Race models and analogy theories: A dead heat? Reply to Seldenberg. Cognition, (in press).

254. NORRIS, D.G., & CUTLER, A. Juncture detection as a processing universal. Linguistics, (in press).

255. NORRIS, D.G., & NIMMO-SMITH, I. Naming and lexical decision: How big is the word frequency effect. (Manuscript submitted).

256. OAKHILL, J.V., & JOHNSON-LAIRD, P.N. (1984) The representation of spatial descriptions in working memory. Current Psychological Research and Reviews, 3, 52-62.

257 . OAKHILL, J.V., & JOHNSON-LAIRD,' P.N. Rationality, memory, and the search for counterexamples. (Manuscript submitted).

258. OAKHILL, J.V., & JOHNSON-LAIRD, P.N.... The effects of belief on the spontaneous production of syllogistic conclusions. (Manuscript submitted).

259. OGILVIE, R.D., & HOUGHTON, D. (1982) A simple respiration transducer. Electroencephalography and Clinical Neurophysiology, 54, 347-348.

260. OGILVIE, R.D., & WILKINSON, R.T. (1983) Behavioural and physiological indicators of sleep onset. In: Sleep Research. M.H. Chase, W.B. Webb and R. Wilder-Jones (eds.), Los Angeles: Brain Information Services/Brain Research Institute 12, p. 162.

261. OGILVIE, R.D., & WILKINSON, R.T. (1984) The detection of sleep onset: Behavioral and physiological convergence. Psychophysiology, 21, 510-520.

262. O'SHEA, T., YOUNG, R.H., EVERTSZ, R., JONES, A., MELLIS, W., SCANLON, E., FLOYD, A., & KAHNEY, H.

Feasibility of production rule modelling: Ten case studies. (Manuscript in preparation).

263. PAJURKOVA, E., & WILKINS, A.J. Prospective remembering in patients with unilateral temporal frontal lobectomies. Paper read at International Psychology Society Meeting, 1983. (Manuscript in preparation for publication).

264. PATTERSON, K.E. Acquired disorders of spelling. In: Perspectives in Cognitive Neuropsychology. G.

Denes, C. Semenza, P. Blsiacchi and E. Andreewsky (eds.), London: Lawrence Erlbaum, (in press).

265. PATTERSON, K.E. Agrammatism in a single modality. (Manuscript in preparation).

266. PATTERSON, K.E., & 8ESNER, D. (1984a) Is the right hemisphere literate? Cognitive Neuropsychology, 1, 315-341.

267. PATTERSON, K.E., & BESNER, D. (1984b) Reading from the left: A reply to Rabinow1cz and Moscovitch and to Zaidel and Schweiger. Cognitive Neuropsychology, 1, 365-380.

268. PATTERSON, K.E., & COLTHEART, M. Acquired disorders of reading: A psycholinguistic description. In: Aphasia. J. Oxbury, R. Whurr, M. Wyke and M. Coltheart (eds.), London: Butterworths, (in press).

269. PATTERSON, K.E., & HOWARD, D. The single case paradigm: Methodological Issues in neuropsychological therapy. To appear in: Cognitive Approaches in Neuropsychological Rehabilitation. X. Seron and G. Deloche (eds.), London: Erlbaum. (Manuscript in preparation).

270. PATTERSON, K.E., & KAY, J. (1982) Letter-by-letter reading: Psychological descriptions of a neurological syndrome. Quarterly Journal of Experimental Psychology, 34A, 411-441.

271. PATTERSON, K.E., MARSHALL, J.C, & COLTHEART, M. (eds.) Surface Dyslexia. London: Erlbaum, (in press).

272. \* PATTERSON, K.E., & MORTON, J. From orthography to phonology: An attempt at an old interpretation.
In: Surface Dyslexia. K. Patterson, J.C. Marshall and M. Coltheart (eds.), Condon: Erlbaum, (in press).
273. PATTERSON, K.E., MORTON, J., & FRANKLIN, S. (1983) Word retrieval in aphasia: Facilitation and therapy. Final Report on a project from the DHSS, July 1983.

274. PATTERSON, K.E., & SHEWELL, C. Deep dysgraphia and dissociations in spelling/speaking. In: Cognitive Neuropsychology of Language. M. Coltheart, R. Job and G. Sartorlo teos.I, London: Lawrence Erlbaum, (in press).

275. \* PATTERSON, R.D. (1982a) Guidelines for auditory warning systems on civil aircraft. Institute for
Perception Research, IPO Report No. 413. Al so appears as a Civil Aviation Authority paper No. 82017 (1982).
276. PATTERSON, R.D. (1982b) Review of the auditory warning system proposed in ARINC 726. U.K. Civil
Aviation Authority, Contract No. 7D/S/0260/3, Final Rep"orT^ '

277. PATTERSON, R.D. (1983) Guidelines for auditory warning systems on civil aircraft: A summary and a prototype. In: Noise as a Public Health Problem, Proceedings of the Fourth International" Congress Vol. 2. G. Rossi (ed.), Milan: Centro Ricerche e Studi Ampfifon, pp. 1125-1133.

278. PATTERSON, R.D. Voice- communications. In: Human Factors for Designers of Naval Equipment. MRC Royal Naval Personnel xesearcn Committee, Psychology Subcommittee, (in press).

279. PATTERSON, R.D., BARTON, J., & MILROY, R. (1982) The appropriate sound level for the configuration horn on the BAC 1-11 aircraft. UK Civil Aviation Authority, Contract No. 7D/S/0260/1 Stage I "Final- Report.

280. PATTERSON, R.D., & MILROY, R. (1982) Auditory warnings on the Boeing 747. UK Civil Aviation Authority, Contract No. 7D/S/0260/1 Stage II, Final Report.

281. PATTERSON, R.D... MILROY, R., & LUTFI, R.A. (1983) Detecting a repeated tone burst in repeated noise. Journal of the Acoustical Society of America, 73,-951-954.

282. PATTERSON, R.D., & MOORE, B.C.J. Auditory filters and excitation patterns as representations of frequency resolutions. In: Selectivity in Hearing. B.C.J. Moore (ed.), Academic Press, (1n press).;

283. \* PATTERSON, R.D., NIMMO-SMITH, I., WEBER, D.L., & MILROY, R. (1982) The deterioration of hearing with age: Frequency selectivity, the critical ratio, the audiogram, and speech threshold. Journal of the Acoustical Society of America, 72, 1788-1803.

284. PATTERSON, R.D., NIMMO-SMITH, I., WEBER, D.L., & ZELLE, H.W. (1981) The deterioration of frequency selectivity with age. Institute of Perception Research, IPO Progress Report No. 16.

285. PATTERSON, R.D., PETERS, R.W., & MILROY, R. (1983) Threshold duration for melodic pitch. In: Hearing - Physiological Bases and Psychophysics. (Proceedings of the 6th International Symposium on Hearing, Bad Nauheim, Germany). R. Klinke and R. Hartmann (eds.), Berlin: Springer Verlag, pp. 321-326.

286. DA COSTA PINTO, A. Serial position effects in long-term memory tasks. Unpublished PhD Thesis, Universidade do Porto.

287. POSNER, M.I., & McLEOD, P. (1982) Information processing models - in search of elementary operations. Annual Review of Psychology, 33, 477-514.

288. POULTON, E.C. (1981) Not so! Rejoinder to Hartley on masking by continuous noise. Psychological Review, 88, 90-92.

289. POULTON, E.C. (1982a) Biases in quantitative judgments. Applied Ergonomics, 13, 31-42.

290. POULTON, E.C. (1982b) Influential companions: Effects of one strategy on another in the w1thin-subjects designs of cognitive psychology. Psychological Bulletin, 91, 673-690.

291. POULTON, E.C. Bias in Judgment. San Francisco: Academic Press, (in press).

292. POULTON, E.C. A linear relation between loudness and decibels. Perception and Psychophysics, (in press). 293. POULTON, E.C. Subjective zeros, subjectively equal stimulus spacing, and contraction biases in very first judgments of lightness. (Manuscript submitted).

294. POULTON, E.C. Asymmetric transfer bias in human factors Investigations. (Manuscript submitted).

295. POULTON, E.C. Geometric illusions 1n reading graphs. (Manuscript submitted).

295a. PROBERT, D., & YOUNG. R.M. (1985) Report on the joint MM1/IKBS workshop on applications driven research. SERC/Alvey Directorate.

296. ROLFE, J., & BEKERIAN, D.A. Witnesses. In: Proceedings of ISASI Conference, In press).

297. RYDER, A. Schizophrenia, asymmetry and laterality: A review. Irish Journal of Psychology, (in press).

298. RYDER, A. Computed axial tomography in Schizophrenia: A review and Implications for research.

(Manuscript submitted).

299. RYDER, A., & WILKINSON, R.T. Moderate intermittent noise effects on a memory comparison task. (Manuscript in preparation).

300. RYDER, A., & WILKINSON, R.T. Individual differences and effects of moderate intermittent noise on

performance. (Manuscript in preparation).

301. \* SALAMI:, P., & BADDELEY, A.O. (1982) Disruption of short-term memory by unattended speech: Implications for the structure of working memory. Journal of Verbal Learning and Verbal Behavior, 21, 150-164.

302. SALAMI, P., & BADDELEY, A.D. (1983) Differential effects of noise and speech on short-term memory. In: Noise as a Public Health Problem, Proceedings of the Fourth International Congress Vol. 2. G. Rossi (ed.), Milan: Centro Ricerche e Studi AmplUon, pp. 751- 758.

303. SCOTT, D.R., & CUTLER, A. (19B4) Segmental phonology and the perception of syntactic structure. Journal of Verbal Learning and Verbal Behavior, 23, 450-466.

304. SCOTT, W.A.C., WHITMAN, J.G., & WILKINSON, R.T. (1983) Choice reaction time. ' A method of measuring postoperative psychomotor performance decrements. Anaesthesia, 38, 1162-1168.

305. SEGUI, J., MEHLER, J., FRAUENFELDER, U., & MORTON, J. (1982) The word frequency effect and lexical access Neuropsychologia, 20, 615-627.

306. \* SHALL ICE, T. (1982) Specific impairments of planning. Philosophical Transactions of the Royal Society London B, 298, 199-209

307. SHALLICE, T. (1984) More functionally isolable subsystems but "fewer" modules. Cognition, 17, 243-252.308. SHALLICE, T. Consciousness and its disorders. In: The Social Science Encyclopaedia. A. Kuper and J. Kuper (eds.), Koutledge and Kegan Paul, (In press).

309. SHALUCE, T. Impairments of semantic processing: Multiple dissociations. In: The Cognitive Neuropsychology of Language. M. Coltheart, R. Job and B. Sartorl (eds.J, London: Lawrence Erlbaum Associates, (in press).

310. SHALLICE, T., & McCARTHY, R. Phonological reading: From patterns of impairment to possible procedures. In: Surface Dyslexia. K.E. Patterson, J.C. Marshall and M. Coltheart Ieds.), London: Erlbaum, (in press).

311. SHALLICE, T., McLEOD, P., & LEWIS, K. Isolating cognitive modules with the dual task paradigm: Are speech perception and production separate processes? (Manuscript in preparation).

312. SHALLICE, T., & SAFFRAN. E. Affix stripping and lexical decision In the absence of explicit word Identification evidence from a letter-by-letter'reader. (Manuscript in preparation).

313. SHALLICE, T., WARRINGTON, E.K., & McCARTHY, R. (1983) Reading without semantics. Quarterly Journal of Experimental Psychology, 35A, 111-138. —

314. SILVERMAN, K.E.A. (1984a) What causes vowels to have intrinsic fundamental frequency? Cambridge Papers in Phonetics and Experimental Linguistics, 3, 1-lb.

315. SILVERMAN, K.E.A. (1984b) FO perturbations as a function of voicing of prevocalic and postvocalic stops and fricatives, and pf syllable stress. In: Proceedings of the Institute of Acoustics, (Autumn Conference) Vol. 6. Part 4, pp. 445-452.

315. SMYTH, M.M., & WING, A.M. (eds.) The Psychology of Human Movement. New York: Academic Press, (in press).

317. SMYTH, M.M., & WING, A.M. Movement, action and skill. In: The Psychology of Human Movement. M.M.

Smyth and A.M. Wing (eds.), New York: Academic Press, (in press).

318. SMYTH, M.M., & WING A.M. Afterword. In: The Psychology of Human Movement. M.M Smyth and A.M. Wing (eds.), New York: Academic Press, (in press).

319. SPINNLER, H., DELLA SALA, S., BANDERA, R., & BADDELEY, A. Dementia, ageing and fJie structure of human memory. (Submitted for publication).

320. \* SUNDERLAND, A., HARRIS, J.E., & BADDELEY, A.D. (1983) Do laboratory tests predict everyday memory? A neuropsychological study. Journal of Verbal Learning and Verbal Behavior, 22, 341-357.

321. SUNDERLAND, A., HARRIS, J.E., & BADDELEY, A.D. (1984) Assessing everyday memory after severe head injury. In: Everyday Memory, Actions and Absentmindedness. J.E. Harris and P.E. Morris (eds.), London: Academic Press, pp. 191-206.

322. SUNDERLAND, A., HARRIS, J.E., & GLEAVE, J. (1984) Memory failures in everyday life following severe head injury. Journal of Clinical Neuropsychology, 6\_, 127-142.

323. THOMSON, G.A. (1982a) Do measurements of motorcycle conspicuity really measure conspicuity effects? Ergonomics, 25, 771-782.

324. THOMSON, G.A. (1982b) Some effects of taxonomic grouping on choice reaction to visual word stimuli: Variations 1n number of groups and Inter-group probability differences. Unpublished PhD Thesis, University of Cambridge.

325. TILLEY, A.J. Recovery sleep at different times of the night following loss of the last 4 hours of sleep. Sleep, (in press).

326. TILLEY, A.J., & WARREN, P.S.G. (1983) Retrieval from semantic memory at different times of day. Journal of Experimental Psychology: Learning, Memory and Cognition, 9, 718-724.

327. TILLEY, A.J., & WARREN. P.S.G. (1984) Retrieval from semantic memory during a night without sleep. Quarterly Journal of Experimental Psychology, 36A, 281-289.

328. TILLEY, A.J., & WILKINSON, R.T. (1984) The effects of a restricted sleep regime on the composition of sleep and on performance. Psychophysiology, 21, 406-412.

329. TILLEY, A.J., WILKINSON, R.T., WARREN, P.S.G., WATSON, B., & DRUD, M. (1982a) Night and day shifts compared in terms of efficiency at work and the quality of sleep at home. In: Shiftwork, Quantity and quality of Sleep: Individual Differences. European Foundation for the Improvement of living and working conditions. Dublin: European Foundation Publication, pp. 34.

330. \* TILLEY, A.J., WILKINSON, R.T., WARREN, P.S.G., WATSON, B., & DRUD, M. (1982b) The sleep and performance of shift workers. Human Factors, 24, 629-641.

331. TYLER, L.K. (1984) Integration of information during language comprehension: A developmental study.In: Proceedings of the Stanford Child Language Research Forum.

332. TYLER, L.K. The sequential organisation of spoken word recognition. In: Studies in Natural Language Processing. F. Fall side and N. WoodsTeds.), Cambridge University Press, (in press).

333. TYLER, L.K. The structure of the Initial cohort: Evidence from gating. Perception and Psychophysics, (1n press).

334. TYLER, L.K., & WESSELS, J. (1983) Quantifying contextual contributions to word recognition processes.

Perception and Psychophysics, 34, 409-420.

335. TYLER, R.S., HALL, J.W., GLASBERG, B.R., MOORE, B.C.J., & PATTERSON, R.D. (1984) Auditory filter
asymmetry in the hearing Impaired. Journal of the Acoustical Society of America, 76, 1363-1368
336. VALLAR, G., & BADDELEY, A.D. (1982) Short-term forgetting and the articulatory loop. Quarterly Journal of Experimental Psychology, 34A, 53-60.

337. VALLAR, G., & BADDELEY, A.D. (1984a) Fractionation of working memory. Neuropsychological evidence for a phonological short-term store. Journal of Verbal Learning and Verbal Behavior, 23, 151-161.
338. VALLAR, G., & BADDELEY, A.D. (1984b) Phonological short-terra store, phonological processing and sentence comprehension: A neuropsychological case study. Cognitive Neuropsychology, 1, 121-141.

339. \* WARRINGTON, E.K., & SHALLICE, T. (1984) Category specific semantic impairments. Brain, 107, 829-854.

340. WASTELL, D.G., BROWN, I.D., & COPEMAN, A.K. (1982) Differential effects of workload on system performance in cord and cordless public telephone switchrooms. Ergonomics, 25, 1041-1052.

341. WASTELL, D.G., KLEINHAN, D, & MACLEAN, A. (1982) Temporal uncertainty and the "refractoriness" of the human vertex evoked potential. Bulletin of the Psychonomic Society, 19, 155-158.

342. WASTELL, D.G., WILKINS, A.J., & DARBY, C.E. (1982) Self-induction of epileptic seizures by eye closure:
Spectral analysis of concomitant EEG. Journal of Neurology, Neurosurgery and Psychiatry, 45, 1151-1152:
343. WATT, R.J. (1984) Towards a general theory of the visual acuities for shape and spatial arrangement.
Vision Research, 24, 1377-1386.

344. WATT, R.J. Structured representation in low-level vision. Nature, (in press).

345. WATT, R.J. Image segmentation at contour intersections in human focal vision. Journal of the Optical Society of America, (in press).

346. WATT, R.J. Feature-based image segmentation in human vision. (Manuscript submitted).

347. WATT, R.J., & CAMPBELL, F. Vernier acuity: Interactions between length effects and gaps when orientation cues are eliminated. (Manuscript submitted).

348. WATT, R.J., & HESS, R. Spatial information and uncertainty in amblyopia. (Manuscript 1n preparation). 349. WATT, R.J., & MORGAN, M. A theory of the primitive spatial code in human vision. Vision Research (in press).

350. WATT, R.J., & WARD, R. The detection of deviation from stralghtness in lines. (Manuscript in preparation). 351. WATTS, F.N. (1982a) What makes a competent therapist? In: Psychiatric Treatment - Art or Science? A Report of MIND's 1981 Annual Conference. London: M1nd Publications, pp. 17-21.

352. WATTS, F.N. (1982b) Attributional aspects of medicine. In: Attributions and Psychological Change. C. Antaki and C. Brewin (eds.). Academic Press, pp. 13b-lbb.

353. WATTS, F.N. (1983a) Affective cognition: A sequel to Zajonc and Rachman. Behaviour Research and Therapy, 21, 89-90.

354. WATTS, F.N. (1983b) Mental illness. In: The Practice of Clinical Psychology in Great Britain. A. Uddell (ed.), John Wiley, pp.

355. WATTS, F.N. (1983c) Introduction: The concept of rehabilitation. In: Theory and Practice of Psychiatric

Rehabilitation. F.N. Watts and D.H. Bennett (eds.), John Wiley, pp. 3-14.

356. WATTS, F.N. (1983d) Employment. In: Theory and Practice of Psychiatric Rehabilitation. F.N. Watts and D.H. Bennett (eds.), John Wiley, pp. 215-240.

357. WATTS, F.N. (1983e) Socialization and social integration. In: Theory and Practice of Psychiatric

Rehabilitation. F.N. Watts and D.H. Bennett (eds.), John Wiley, pp. 289-310.

358. WATTS, F.N. (1983f) Training in clinical psychology: A reply to Newson et al. - Bulletin of the British Psychological Society, 36,

359. WATTS, F.N. (1983g) Magical therapy - just a bag of tricks. The Psychology and Psychotherapy Journal -Changes, 1, 44-45.

360. WATTS, F.N. (1983h) Strategies of clinical listening. BritIsh Journal of Medical Psychology, 56, 113-123.

361. WATTS, F.N. (1984) Applicable psychological research in the NHS. Bulletin of the British Psychological Society, 37, 41-42.

362. WATTS, F.N. Rehabiliation programmes for psychiatric patients. In: A Handbook of Clinical Psychology. S. Lindsey and G.E. Powell (eds.), London: Gower, (in press).

363. WATTS, F.N. (ed.) New Developments in Clinical Psychology. Leicester: British Psychological Society, (in press).

364. WATTS, F.N. Listening processes in psychotherapy. In: Directions in Psychiatry, Vol. S. F.F. Flach (ed.), New York, (in press).

365. WATTS, F.N. Clinical psychology. Health Trends, (in press).

366. WATTS, F.N. Cognitive aspects of phobias. Behavioural Analysis, (in press).

367. WATTS, F.N., & BENNETT, D.H. . (1983a) Neurotic, affective and conduct disorders. In: Theory and Practice of Psychiatric Rehabilitation. F.N. Watts and D.H. Bennett (eds.), John Wiley, pp. 65-82.

368. WATTS, F.N., & BENNETT, D.H. (1983b) Management of the staff team. In: Theory and Practice of Psychiatric Rehabilitation. F.N. Watts and D.H. Bennett [eds.), John Wiley, pp. 313-3Z8.

369. WATTS, F.N., & LAVENDER, A. Assessment in psychiatric rehabilitation. In: A Handbook of Clinical Psychology. S. LIndsey and G.E. Powell (eds.), London: Gower, (in press).

370. WATTS, F.N., & SHARROCK, R., (1984a) Fear and time estimation. Perceptual and Motor Skills, 59, 597-598.

371. WATTS, F.N., & SHARROCK, R. (1984b) Questionnaire dimensions of spider phobia. Behaviour Research and Therapy, 22, 575-580.

372. WATTS, F.N., & SHARROCK, R. Relationships between spider constructs in phobics. British Journal of Medical Psychology, (in press).

373. WATTS, F.N., & SHARROCK, R. Description and measurement of concentration problems in depressed patients. Psychological Medicine, (in press).

374. WATTS, F.N., SHARROCK, R., & TREZISE, L. Detail and elaboration in phobic imagery. (Manuscript submitted).

375. WATTS, F.N., SHARROCK, R., & TREZISE, L. Colour-naming of phobia-related words. (Manuscript in preparation).

376. WATTS, F.N., & TREZISE, L. Memory for phobia-related words 1n spider phobics. (Manuscript 1n preparation).

377. WATTS, F.N., TREZISE, L., & SHARROCK, R. Recognition memory for phobic stimuli. (Manuscript submitted).

378. WATTS, K.P., BADDELEY, A.D., & WILLIAMS, M. (1982) Automated tailored testing using Raven's Matrices and the Mill Hill Vocabulary Tests: A comparison with manual administration. International Journal of Man-Machine Studies, 17, 331-344.

379. WEBER, D.L., & PATTERSON, R.D. (1984) Sinusoidal and noise maskers in simultaneous and forward masking. Journal of the Acoustical Society of America, 75, 925-931.

380. WILKINS, A.J. (1983) Are there any medical conditions, such as epilepsy, which should preclude employees using visual display units? British Medical Journal, 287, 482.

381. WILKINS, A.J. (1984) Visual discomfort and cathode ray tube displays. In: INTERACT '84 First IFIP Conference on -Human-Computer Interaction Vol.1 London: International Federation for Information Processing, IEE, pp. 76-80.

382. WILKINS, A.J. Visual sensitivity and hyperexcitability. In: Migraine and Epilepsy. F. Andermann and E. Lugaresi (eds.), Woburn, Mass.: Butterworths, (in press).

383. WILKINS, A.J. Visual display units and fluorescent lighting affect movements of the eyes across texts. (Manuscript submitted)

384. WILKINS, A.J., BINNIE, CO., & DARBY, D.E. (1981) Interhemispheric differences in photosensitive epilepsy: I. Pattern-sensitivity thresholds. Electroencephalography and Clinical Neurophysiology, 52, 461-468. 385. WILKINS, A.J., & LINDSAY, J. (1985) Common forms of reflex epilepsy: Physiological mechanisms and techniques for treatment. In: Recent Advances in Epilepsy II. T.A. Pedley and B.S. Meldrum (eds.), Edinburgh: Churchill Livingstone, pp. 239-271.

306. WILKINS, A.J., & NIMMO-SMITH, 1. (1984) On the reduction of eye-strain when reading. Ophthalmic and Physiological Optics, 4, 53-59.

387. WILKINS, A.J., & NIMMO-SMITH, I. On the clarity and comfort of text. (Manuscript in preparation). 388. \* WILKINS, A.J., NIMMO-SMITH, I., TAIT, A., McMAMIS, I.C., DELLA SAL A, S., TILLEY, A., ARNOLD, K., BARRIE, M.A., & SCOTT, S.G.C. (1984) A neurological basis for visual discomfort. Brain, 107, 989-1017. 389. WILKINS, A.J., SHALLICE, T., & MCCARTHY, R. Frontal lobe lesions impair the ability to sustain attention. (Manuscript in preparation).

390. WILKINS, A.J., ZIFKIN, B., ANDERMANN, F., & McGOVERN, E. (1982) Seizures induced by thinking. Annals of Neurology, 11, 608-612.

391. WILKINSON, R.T. (1981) Effects of traffic noise upon sleep in the home: Subjective report, EEG, and performance the next day. In: Sleep, 1980.. W.P. Koella (ed.), Basel: Karger, pp. 225-228.

392. WILKINSON, R.T. (1984a) Disturbance of sleep by noise: Individual differences.. Journal of Sound and Vibration, 95, 55-63.

393. WILKINSON, R.T. (1984b) The effect of traffic noise upon physiological and subjective assessment of sleep and upon subsequent performance. Commission of the European Communities, Contract No.- ENV-506-
UK(H), Interim Report, March, 1984.

394. WILKINSON, R.T. (1984c) The effect of noise peaks and pseudo peaks compared on ECG--a follow-up to the previous EEG analysis. Commission of the European Communities, Contract No. ENV-506-UK1H), Interim Report, September, 1984.

395. WILKINSON, R.T. Disturbance of sleep by noise: Interpersonal differences. In: Proceedings CIB/CIE Workshop on "Persons not People", Electricity Council Research Centre, Chester, 1982: Cameleon Press, (in press).

396. WILKINSON, R.T., & ALLISON, S. (1982) N200 and simple unprepared reaction time. Psychophysiology, 19, p. 592.

397. WILKINSON, R.T., & ALLISON, S. (1983) Effects of peaks of traffic noise during sleep on ECG and EEG.In: Noise as a Public Health Problem, Proceedings of the Fourth International Congress. Vol 77 G. Rossi (ed.),Milan: Centro Ricerche e studi Amplifon, pp. 957-963.

397a. WILKINSON, R.T., & ALLISON, S. Endogenous evoked potentials and loss of sleep. International Journal of Psychophysiology, (in press).

398. \* WILKINSON, R.T., & CAMPBELL, K. (1984) Effects of traffic noise on quality of sleep: Assessment by EEG, subjective report, or performance the next day. Journal of the Acoustical Society of America, 75, 468-475.

399. \* WILKINSON, R.T., & HOUGHTON, D.A. (1982) Field test of arousal: A portable reaction timer with data storage. Human Factors, 24, 487-493.

400. WILLIAMS, J.M.G. (1984a) The Psychological Treatment of Depression: A Guide to the Theory and Practice of Cognitive-Behaviour Therapy. London: Croom Helm, pp. 231.

401. WILLIAMS, J.M.G. (1984b) Cognitive-behaviour therapy for depression: problems and perspectives. British Journal of Psychiatry, 145, 254-262.

402. WILLIAMS, J.M.G. Attempted suicide. In: New Developments in Clinical Psychology. Leicester: British Psychological Society Publication, in press).

403. WILLIAMS, J.M.G. The attributional reformulation of depression as a diathesis-stress model: Metalsky et al. reconsidered. Journal of Personality and Social Psychology, (in press).

404. WILLIAMS, J.M.G. Depression. In: Handbook of Social Skills Training. P. Trower and C. Hollin (eds.), Pergamon Press, (1n press).

405. WILLIAMS, J.M.G. Level of hopelessness and the reasons people give for taking overdoses. (Manuscript in preparation).

406. WILLIAMS, J.M.G., & BROADBENT, K. Autobiographical memory in suicide attempters. (Manuscript in preparation).

407. WILLIAMS, J.M.G., & BROADBENT, K. Sensitivity to general and specific emotional stimuli in suicide attempters. (Manuscript in preparation).

408. WILLIAMS, J.M.G., & NULTY, D.D. Construct accessibility in depression: Transient mood or stable structure? (Manuscript in preparation).

409. WILSON, B-, & BADDELEY, A.D. Single case methodology and the remediation of dyslexia. In: Dyslexia:

Neuropsychology and Treatment. G.Th. Pavlidis and D.F. Fisher (eds.), London: John Wiley & Sons Ltd., (In press).

410. WILSON, B., BADDELEY, A.D., & HUTCHINS, H. (1984) The RIvermead Behavioural Memory Test. Rivermead Technical Report 84/1.

411. WILSON, M.D. (1984a) Composition of the mental lexicon. Unpublished PhD thesis. University of Cambridge.

41.2. WILSON, M.D. (1984b) Health, health-care and the state. In: Community Health Care Compared with England and Poland 1982 and 83. C.T Wilson, S. Potkowska, M. Hammond and M. Ziemska (eds.), London: North East London Polytechnic, pp. 98-108.

413. WILSON, M.D., BARNARD, P.J., & MACLEAN, A. The acquisition and performance of basic task sequences for an integrated software package. - IBM Hursley Human Factors Report. (Manuscript in preparation)":

414. \* WING, A. (1982) Timing and co-ordination of repetitive bimanual movements. Quarterly Journal of Experimental Psychology, 34A, 339-348.

415. WING, A. (1983) Crossman and Goodeve (1963): Twenty years on. Quarterly Journal of Experimental Psychology, 35A, 245-249.

416. WING, A.M. (1984) Introduction. In: Timing and Time Perception, J. Gibbin and L. Allan (eds.). Annals of the New York Academy of Sciences, Vol. 423, p. 143.

417. WING, A.M. Disorders of movement. In: The Psychology of Human Movement. M.M. Smyth and A.M. Wing (eds.), New York: Academic Press, (in press).

418. WING, A., & FRASER, C. (1983) The contribution of the thumb to reaching movements. Quarterly Journal of Experimental Psychology, 35A, 297-309.

419. WING, A.M., KEELE, S., 8 MARGOLIN, D.I. (1984) Motor disorder and the timing of repetitive movements. In: Timing and Time Perception, J. Gibbin and L. Allan (eds.), Annals of the New York Academy of Sciences, Vol. 423, pp. 183-192.

420. WING, A.M., 4 MILLER, E. (1984a) Research Note: Peak velocity timing invariance. Psychological Research, 46, 121-127.

421. WING, A.M., 4 MILLER, E. (1984b) Basal ganglia lesions and psychological analyses of the control of voluntary movements. In: Functions of the Basal Ganglia. (Ciba Foundation Symposium 107). London: Pitman, pp. 242-257.

422. WING, A., NIMMO-SMITH, I., 4 ELDRIDGE, M. (1981) The Variability of Cursive Handwriting: A Final Report on the research carried out under £ne Home fiffice/MRC contract on within- and between-individual variation of handwriting features.

423. WING, A., NIMMO-SMITH, I., 4 ELDRIDGE, M. (1983) The consistency of cursive letter formation as a function of position in the word. Acta Psychologica, 54, 197-204.

424. WING, A.M., TURTON, A., 4 FRASER, C. Compensatory adjustments to grasp and approach errors in reaching. (Manuscript in preparation).

426. WRIGHT, P. (1981a) The instructions clearly state can't people read? Applied Ergonomics, 12, 131-141.426. WRIGHT, P. (1981b) Informed design for forms. Information Design Journal, 2, 151-178.

427. WRIGHT, P. (1981c) Problems to be solved when creating usable documents. In: Proceedings of IBM Symposium on Software and Information Usability. (IBM Human Factors, Hursley Park, Winchester HF.077), pp. 53-103.

428. WRIGHT, P. (1982a) Die Funktion bestimmt die Struktur bei der Gestaltung von Tabellen in technischer Literatur. Papier und Druck, 31\_, 2, 30-32.

429. WRIGHT, P. (1982b) Human factors in computer-based education: Creating the links between research and application. In: Proceedings of CBE Research Past, Present and Future. University of Delaware, June 1982.
430. WRIGHT, P. (1983a) Can ergonomics go on working? Contemporary Psychology, 28, 129-130.

431. WRIGHT, P. (1983b) Writing and reading technical Information. In: Psychology Survey No. 4. J. Nicholson and B. Foss (eds.), Leicester: The British Psychological Society, pp. 323-354.

432. WRIGHT, P. (1983c) Rayner one year later. Information Design Journal, 3/3 (special Issue: Information design and information technology!?" 246-249.

433. WRIGHT, P. (1983d) Technical communication: English for very special purposes. In: The British Association for Applied Linguistics, Newsletter No. 18, Summer 1983, pp. 24-29.

434. WRIGHT, P. (1983e) Manual dexterity - a user-oriented approach to creating computer documentation. In: CHI '83 Conference Proceedings on Human Factors in Computing Systems. JT. Janda (ed.), Boston: ACM, pp. 11-18.

435. WRIGHT, P. (1984a) Designing the documentation that explains how IT works. Design Studies, S\_, 73-78.
436. WRIGHT, P. (1984b) User documentation. In: Proceedings of the World Conference on Ergonomics in Computer Systems. September, 1984, Ericsson: Information Systems, pp. 109-126.

437. \* WRIGHT, P. (ed.) (1984c) Some effects of communications medium on visible language. Visible Language (Special Issue), XVIII, (2).

438. WRIGHT, P. (1984d) The contribution of psychology to Information design: Organiser' A overview and summary. In: Proceedings of

the XXIII International Congress of Psychology. Mexico, September, '1984, p. 1967

439. WRIGHT, P. Editorial policies and processes. In: Towards More Usable Texts. T. Duffy and R.H. Waller (eds.), Academic Press, (in press).

440. WRIGHT, P. Is evaluation a myth? Assessing text assessment procedures. In: The Technology of Text,

Vol. 2. D. Jonassen (ed.), Englewood CI if f s, N.J.: Educational Technology Publications, (in press).

441. WRIGHT, P. Review of: M. Nystrand (ed.) "What writers know: the language process and structure of written discourse". New York: Academic Press, 1982. Applied PsycholInguistics, (in press).

442. WRIGHT, P. Form and function. -Review of J.F. Burgess Human Factors in Forms Design. Contemporary Psychology, (in press).

443. WRIGHT, P. Document Design: Psychological Research and Theory. Cambridge University Press, (in pre'ss).

444. WRIGHT, P. Reading and writing for electronic Journals. In: Executive Control Processes in Reading. B. BMtton (ed.), Hil 1 sdal e, N..J.: Lawrence Erlbaum Associates., (manuscript in preparation).

445. \* WRIGHT, P., & BASON, G. (1982) Detour routes to usability: A comparison of alternative approaches to

multipurpose software design. International Journal of Man-Machine Studies, 18, 391-400. '

446. WRIGHT, P., CREIGHTON, P., & THRELFALL, S.M. (1982) Some factors determining when instructions will be read. Ergonomics, 25, 225-237.

447. WRIGHT, P., & HAYBITTLE, J. Designing clinical trial forms to collect the right data. In: Handbook of Clinical Drug Research. H. Glenny and P. Nelmes (eds.), Blackwell Scientific Publications Ltd., (in press).

448. WRIGHT, P., & HULL, A.J. Answering questions about negative conditionals. Journal of Verbal Learning and Verbal Behavior, (in press).

449. WRIGHT, P., & HULL, A.J. Readers' representations of conditional information: Until and while. (Manuscript in preparation).

450. WRIGHT, P., & HULL, A.J. Recoding options and strategy selection for negative conditionals. (Manuscript in preparation).

451. WRIGHT, P., HULL, A.J., & LICKORISH, A. (1984) Psychological factors in reading tables. In: Proceedings of the XXIII International Congress of Psychology, Mexico, 1984, p. 194.

452. WRIGHT, P., & LICKORISH, A. (1983) Proof reading texts on screen and paper. Behaviour and Information Technology, Z\_, 227-235.

453. WRIGHT, P., & LICKORISH, A. (1984a) Ease of annotation in proof-reading tasks. Behaviour and Information Technology, 3, 185-194.

454. WRIGHT, P., & LICKORISH, A. (1984b) Investigating referees' requirements in an electronic medium. Visible Language, (Special Issue), XVIII (2), pp. 186-205.

455. WRIGHT, P., LICKORISH, A., & WHALLEY, P. Experimental comparison of reading lengthy texts on either CRT screen or paper. In: Forum '85 sponsored by the International Council for Technical" Communication, (in press).

456. YOUNG, R.M. (1982) Architecture-directed processing. In: Proceedings of the 4th Annual Conference of the Cognitive Science Society. Ann Arbor, Michigan, pp. 164-lob.

457. \* YOUNG, R.M. (1983) Surrogates and mappings: Two kinds of conceptual models for interactive devices. In: Mental Models. D. Gentner and A.L. Stevens (eds.), Hillsdale, N.J.: Lawrence Erlbaum Associates, pp. 35-52.

458. YOUNG, R.M. (1984a) Conceptual models of ill-defined systems. In: Adaptive Control of 111-defined Systems. O.G. Selfrldge, E.L. mssland and M.A. Arblb (eds.), NA1U Conference'Series, Series II: Systems Science, Vol. 16. London: Plenum Press, pp. 165-176.

459. YOUNG, R.M. (1984b) Human interface of expert systems. Position paper for the 1st 1KBS Expert Systems Theme Workshop. SERC/Alvey Directorate.

460. YOUNG, R.M. (1984c) An introduction to production systems. Alvey Lecture No. 3: Videotape BC/AL/2 Open University (for the Alvey Directorate).

461. YOUNG, R.M. (1984d) Human interface aspects of expert systems. In: Expert Systems. State of the Art Report 12.7. J. Fox (ed.), Pergamon Infotech Limited, Maidenhead, Berks, pp. 102-111.

461a. YOUNG, R.M. (1984e) Syndicate report on cognitive processes. Alvey MMI Workshop on Human Factors, SERC/Alvey Directorate, pp. 7-10.

462. YOUNG, R.M. Multi-agent model of children's understanding of arithmetic. (Manuscript in preparation).463. YOUNG, R.M., S BARTON, U.S. (1983) Force-sensitive platform for measuring keypresses. Ergonomics, 26, 243-249.

464. YOUNG, R.M., & HULL, A.J. (1982) Cognitive aspects of the selection of viewdata options by casual users.
In: Pathways to the Information Society, (Proceedings of the 6tTi International Conference on Computer Communications, London, pp. 571-576). M.B. Williams (ed.), Amsterdam: North Holland Publishing Co.
465. YOUNG, R.M., S HULL, A.J. (1983) Categorisation structures in hierarchical menus. In: Proceedings of the Tenth International Symposium on Human Factors in Telecommunications, June 1983, Helsinki, Finland, pp. 111-118.