Progress Report
1964-1970

Staff:

Director

D. E. Broadbent, ScD, FRS

Assistant Directors

R. Conrad, PhD (until seconded to The Nuffield Hearing and Speech Centre 1.1.69)

E. C. Poulton, MB, BChir

Scientific Staff

R. G. Adams, BSc 1 September 1970 -

Mrs. J. M. Brand, BA 1 October 1970 -

I. D. Brown, PhD 1 October 1953 -

A. Carpenter, MB 1 April 1949

W. P. Colquhoun, PhD 1 August 1956 -

A. Craig, MA 1 January 1971 -

Miss H. C, Fuller, BA 1 September 1970 -

M. Hammerton, PhD 1 October 1959 -

L. R. Hartley, PhD 1 October 1968 -

C. M. Holloway, PhD 1 October 1968 -

T. J. Hunt, PhD Transferred to Unit 2 February 1970 -

J.B. Long, BA 1 September 1970 -

J. N. T. Martin, MA 1 October 1968 -

P. D. McLeod, BA 1 September 1969 -

B. J. T. Morgan, BSc 1 January 1970 -

J. Morton, PhD 15 October 1960 -

Miss M. T. Spence, PhD 28 September 1970 -

S. D. G. Stephens, MB 1 July 1967 -

R. T. Wilkinson, PhD 1 September 1953 -

Miss M. M. Woodhead Transferred to Unit 23 July 1951 -

Miss P. A. M. Wright, PhD 1 September 1966

Other Senior Staff

A. Davidson (Technical) January 1949 -

Mrs. M. H. P. Gregory, MB (Technical) 1 November 1958 -

Attached Workers

Professor R. N. Haber, Department of Psychology, University of Rochester, New York. 5 September 1970 –

Professor G. Keppel, Department of Psychology, University of California, Berkeley. 5 September 1970 –

J. P. Fox, BSc, (MRC Scholar) 1 October 1970 –

D. R. Godden, BSc, (MRC Scholar) 1 October 1969 -

M. Herbert, BA, (MRC Scholar) 1 October 1970 –

G. J. Hitch, BA, (MRC Scholar) 1 October 1968 -

Previous Scientific Staff

Mrs. P. M. E. Altham, BA 1 September 1965 – 31 December 1969

A. D. Baddeley, PhD 1 September 1958 – September 1967

M. J. F. Blake, BSc August 1962 – died October 1965

E. G. Chambers, MA (Honorarium)

D. W. J. Corcoran, PhD September 1958 – April 1970

H. C. A. Dale, PhD August 1954 – September 1966

Miss K. E. M. Fox, BTech 1 August 1968 – September 1970

P. R. Freeman, MA 1 August 1961 – September 1965

P. Hamilton, PhD 1 March 1968 – August 1970

G. R. J. Hockey, PhD 1 August 1967 – September 1969

J. D. Ingleby, PhD September 1965 – transferred August 1968

Professor D. Kahneman April 1969 – August 1969

J. A. Leonard, PhD 1 January 1953 – March 1965

P. M. A. Rabbitt, PhD 1 September 1960 – December 1967

L. H. Shaffer, PhD 1 October 1959 – September 1965

Previous Attached Workers

Miss N. S. Anderson, PhD, University of Maryland, USA, September 1964 – September 1965

M. Brandon, BA (DSIR NATO Grant), 1964 – August 1965

G. R. J. Hockey, BSc (MRC Scholar) October 1965 – August 1967

R. O. Rouse, Jr., PhD, Williams College, Williamstown, Massachusetts, USA, September 1965 – September 1966

T. B. Roby, PhD., Tufts University, Medford, Massachusetts, USA, October 1965 – September 1966

Miss S. A. Fisher, BSc, (MRC Scholar) October 1966 – October 1968

Professor W. R. Garner, Yale University, USA September 1966 – July 1967

A. J. Sanford, BSc, (MRC Scholar) October 1966 – September 1969

J. C. Webster, PhD, Naval Electronics Laboratory, San Diego, California, USA. September 1966 – July 1967

Miss N. S. Anderson, PhD, University of Maryland, USA, February – August 1968

Professor D. Kahneman, Hebrew University of Jerusalem, August – September 1968

H. Loess, PhD, College of Wooster, Wooster, Ohio, USA, September 1968 –July 1969

M. Posner, PhD, University of Oregon, USA, August 1968 – May 1969

R. O. Rouse, Jr., PhD, Williams College, Williamstown, USA, January – June 1968

Professor S. Glucksberg, Princeton University, USA, August 1969 – January 1970

Professor P. L. Newbigging, McMaster University, Hamilton, Ontario, Canada August 1969 – July 1970

I. Introduction

The nature of the Unit's work makes it difficult to condense into an acceptable number of words. The greater part of it consists of fairly specific projects for outside agencies, about fifty such projects usually being in progress at any one time. With the natural turnover occurring in a seven-year period, it is scarcely possible even to mention every project, let alone summarize it. Accordingly this report will state only certain broad empirical conclusions about human behaviour, and may therefore appear somewhat divorced from practical matters. To guard against such a false picture of the day-to-day work of the Unit, a list is given at Appendix A of the outside agencies for whom work was being conducted at one time in the autumn of 1970; and at Appendix B a list is given of the major committees on which members of the Unit serve. These activities provide the "bread and butter" justification for the Unit's existence: theoretical considerations are secondary.

An overview of the applied work shows a steady shift from military to civilian applications over the last decade. In 1960 the Royal Navy was the dominant outside client, accounting for as much as 50% of the work. (They also provided the great majority of the experimental subjects, loaned important equipment, provided non-graduate assistants, and so on.) This proportion has now fallen to 10-15% while the Post Office is probably the largest single user at about 15-20%. Even an increased demand from the Army (5-10%) has in recent years been only just ahead of the work for the Home Office and the Decimal Currency Board, at about 5% each. As all other minor clients are civilian the dominant tone of the work is now of that type. Correspondingly most experimental subjects come from a panel of civilian volunteers, and all assistance, etc. is provided through the Council. It should be noted however that this is not so much a matter of falling demand from the Services, who have in some ways more pressing human problems than those met in days of simple equipment and more readily available manpower. Rather an overall increase of demand has occurred, which could only be met by spreading the same number of scientists over a wider range of outside enquirers.

The scientific nature of the enquiries has shifted relatively little, doubtless because of the Unit's existing reputation for work on signal detection, division of attention, motor performance, and effects of abnormal environments. These problems arise as much in civilian as in military applications. Even so, there is now an increasing number of enquiries in new areas of psychology, such as the comprehension of instructions (Gas council), the design of artificial codes (Post Office), visual search through large quantities of displayed information (Royal Navy and London Transport) and man-computer interaction (Royal Navy and United

Cambridge Hospitals). As in the relationship of civilian and military work, these new enquiries seem to represent an increase in the total rather than a falling-off in enquiries of traditional type.

II. Scientific Review

A. The Framework

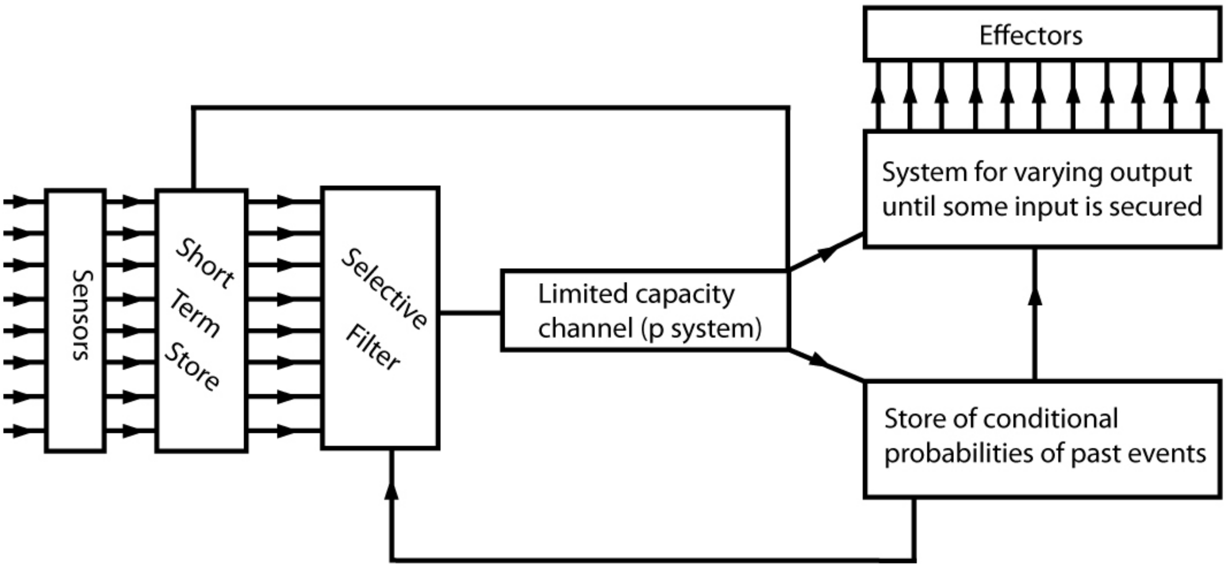
To organize the main empirical findings since 1964, we may relate each of them to various parts of the diagram in Figure 1. This represents flow of information through the nervous system and is taken from Broadbent (1958). Although there are of course disputes about the validity of certain pathways in this diagram it is broadly accepted, and provides a link between the various areas of work. An outline of the diagram is as follows.

The sense organs deliver simultaneously large quantities of information into the CNS: and this information is held very briefly in a kind of buffer or "iconic" storage (Neisser 1967) which can last only a very restricted time. From this store, only a part of the presented information is selected and passes through a stage of limited capacity. This selected part may then produce an action or be held in a further short-term memory restricted to a few items; this memory is possibly mediated by a recurrent loop going back to the buffer store and through the limited capacity system again, but this is controversial. Some of the information from the short-term store does go to a longer-term store which is not restricted by number of items. Lastly, the properties of the whole system may be changed by changes of general state such as sleepiness or excitement.

In the following survey we follow the flow of information through the diagram, which is not necessarily the order of importance of the research. For brevity the conclusions are put somewhat baldly: and only one or two sample reports are quoted in each area. Similarly, references are given by report number, except when they lie outside the period covered by the period of the present list. References to the Unit, but outside the period, are marked *.

B. The Iconic Store

1. Semantic and acoustic similarity. Nowadays it is often necessary to devise code numbers or other symbols to identify people or objects; for example, National Insurance numbers, the Postal Code, or the numbers on MRC Head Office files. The set of symbols used affects the probability of errors in memory: thus the letter J is unlikely to be remembered as Q, but the letter B may be remembered as V. These errors seem to follow the similarity of the sound of the name of the letter. A vocabulary containing both B and V is therefore liable to error. This demonstration that memory errors even for visual material correspond to the similarity of the spoken words describing that material (APU 458) was also of considerable theoretical importance.



It shows that the original iconic store for visual material cannot be the only one involved in short-term memory, but that the incoming information must have been transformed or categorized into another form. This transformed form may be acoustic; or more probably, articulatory since deaf children show similar errors if they have been trained in spoken rather than sign language (APU 818). In ordinary terms, we now have an objective measure of the degree to which people "say things to themselves" when memorizing.

On the other hand, in long-term memory these acoustic similarities are less important than semantic similarity; remembering the wrong word because it means the same as the correct word. It is only in short-term memory that acoustic similarity is more important than semantic similarity is. This reversal of effect has been widely taken as evidence for a distinction between the mechanisms of short-term and long-term memory (APU 626). Hence the distinction of two kinds of memory beyond the iconic store.

It does seem likely however that memory for, e.g. a telephone number, involves the iconic store as well as these later kinds of memory. In everyday life, if you say "Give me 55294 please" the operator is more likely to forget the final 4 than if you say "Please give me 55294". With vision, this effect does not occur. In formal terms, there is an interaction between the nature of the sense organ stimulated by a number, the presence or absence of subsequent events on the same sense, and the presence of errors in the last position of the number (APU 746). The importance of the original sense-organ stimulated means that the stored information has not all been transformed. Thus one can neither exclude the iconic store form such situations, nor regard the combination of such a store with a single long-term memory as sufficient to handle the data.

C. The Filter

2. Decision Theory, Division of attention, and Prolonged Performance. It was naively supposed by Broadbent (1958)* that failures of observation after prolonged work could predominantly be explained by failure to select the appropriate information for the limited capacity part of the system: in ordinary terms, by distraction. Such failures of detection have been a continuing problem both in military systems and in industrial inspection. In so

far as performance is impaired by distraction, one may hope to improve it by changing the way in which information is displayed and the amount of competition from external and irrelevant stimuli. In some situations, this can certainly be done.

However, this analysis assumed that an event is either correctly perceived or completely unobserved, and this is now clearly false. By comparing a man's performance when he is reporting only completely confident percepts, and when he is reporting also perceptions of which he is less confident, we can determine how far the proportion of true percept is increased when he lowers his standard to allow a certain number of "false alarms". It turns out that (a) the relation between the true and false reports is not linear, but concave downward in the way predicted by theories of the brain as a detector carrying out a statistical decision. Without necessarily accepting all the axioms of such a model, we must conclude from the data that there are a number of cases where the man has obtained partial but not definitive evidence of the presence of a stimulus. (b) Distraction of attention reduces the detection rate for a given false alarm rate, but (c) prolonged work in many situations does not do this, but rather reduces both detection and false alarm rates by corresponding amounts (APU 574).

Although workers elsewhere (Mackworth 1970) have found that some kinds of prolonged work do show changes comparable to those of distraction, there is an important class of tasks where the "fatigue" effect is rather a change in parameters of decision or judgement. From a practical point of view, these findings shift the emphasis from the task itself to the training, instructions, and motivation of the man. For example, a foreman or Chief Petty Officer should not regard false reports of signals as heinous crimes; some such reports may be a necessary price for full efficiency.

3. Expectancy in Vigilance. Correspondingly, it is now clear that large changes in the detectability of a simple signal can be produced by changing its probability. Although this has been suspected for many years, most demonstrations of the fact are confounded by other factors; for example, if signals in a task are more frequent, they are certainly more probable, but in addition the total stimulation reaching the observer within the work period is greater. The improvement in his performance might therefore be due to the latter rather than the former cause. It has been clear since the work of Colquhoun (1961)* that efficiency can be unaffected by a change in the rate of arrival of signals, if there is a corresponding increase in the number of non-signal stimuli so as to keep the proportion of signals constant. Conversely, efficiency may change for constant event rate if the proportion of signals changes. This certainly suggests that detection efficiency is controlled by the probability of a signal stimulus.

The point has been made still more conclusively by a series of studies showing that detection rate in a session is affected by changes in the probability of signals experienced during past training sessions. (APU 738). Furthermore, when past experience has been of a high rate of signals, the consequent rises in detection are accompanied by rises in the rate of "False Alarms". That is, the effect of signal probability is to alter the parameters of the decision whether to report a doubtful signal.

Training with inappropriate signal probabilities will also often explain fatigue-like trends in efficiency during a work period. However, changes in signal probability still leave unexplained part of the general downward trend in performance during the work period: thus the effect of prolonged work does not seem reducible to a change in expectancy.

4. Attention allocation. The foregoing results emphasize changes in criteria of judgement, rather than changes in the selection of one part or another of the environmental information. However, such selection is undoubtedly affected by the probability of a signal appearing in one place rather than another. People tend to look in directions where signals have more frequently occurred in the past: a technique, first used in Dundee to show this (APU 67), has been elaborate in the Unit and proves a sensitive test for abnormal environments. Concentration on the most probable source of signals seems fairly certainly to increase in noise; there is a suggestion that it may be reduced by sleeplessness. (APU 813). Thus selective intake of information, as well as biases affecting the subsequent judgements, may indeed be responsible for failure of detection.

D. The Limited Capacity System

5. Reaction Time, Compatibility, and Decision Theory. The time taken for a response is increased when there is a decrease in the probability of that response being required. In the 1950s, the size of this increase was often taken as an inverse measure of the capacity of the central decision process in the nervous system (about 5 or 6 bits/second). However, many experiments have shown that, with given set of possible stimuli and responses, the calculated capacity varies with the "mapping" of particular responses to particular stimuli. With an incompatible relationship, in which the relation of stimulus and response is rather arbitrary, one may find the usual 5 or 6 bits/second; but with a highly compatible relationship, such as pressing down with a finger that has been tactually stimulated, the capacity may be apparently infinite. Furthermore, the degree of compatibility affects the impact of other variables such as the presence of another task or the degree of uncertainty in the time of arrival of the stimulus (APU 532).

Following a very seminal paper by Stone (1960)*, many theorists now regard reaction time as the period necessary for accumulation of sufficient evidence to indicate the correct reaction with an acceptable level of error. The probability of a reaction then affects the criterion appropriate for a decision to make that reaction. Results relating speed, accuracy, and probability seem to support such a view.

6. Word perception. In tasks such as pressing a key when a lamp is lighted, any accumulation of evidence is presumably all of the same kind, and consists of repeated intake of information about the state of the retina. When a spoken or written word is perceived, the chance of a correct percept is affected not only by the amount of sensory information, but also by the semantic context, by the probability of the particular word in the language, and by the grammatical framework in which the word is presented. These different sources of evidence combine in ways which seem reasonably lawful, and which once again suggest that a criteria for perception are adjusted in a way which makes an adaptive use of partially fallible information (APU 742).

7. Combination of evidence. Less purely perceptual and more intellectual is the form of combination of evidence shown by, for example, a listener who has to identify the source of a complex sound with or without a computer-based visual display. In such situations the listener does appear to make use of the computer so that the combined system can be better than man or machine alone. He uses the computer more if the computer is more reliable, or if his own hearing is less satisfactory, but surprisingly and dangerously may turn against the

machine when it combines high reliability on those judgments which are harder for him, with low reliability on his easier ones (APU 773).

Although most of these facts suggest that human judgement combines evidence in the way a statistician might approve, a number of studies in the Unit confirm the result first shown elsewhere, that people are usually less convinced by a given amount of evidence than statisticians would think correct. Possibly for this reason when searching for fresh evidence they do not use the mathematically ideal strategy but rather stick to inefficient systems of search as long as they are occasionally rewarded (APU 477).

8. Scaling of sensory stimuli. The same biases of judgement found in signal detection, word perception, and use of diagnostic evidence, apply also in human judgment of physical magnitudes such as loudness or brightness. Many theorists have placed great significance on the shape of the function relating subjective judgment to physical value, which was long thought to be logarithmic and recently has been regarded as more properly exponential. However, the value of the exponent is greatly influenced by such variables as the range of values presented for judgment, the value of any reference standard, the numerical value the subject is told to assign to any reference, and so on. (APU 682). Such biases must be discounted before any general theory of sensory transduction can be based on subjective judgements of such quantities. The general form of the biases, however, is consistent with the results found in other perceptual and judgmental tasks.

9. Simultaneous Tasks. Because of the limits on the "categorizing" or "decision-making" part of the system, it is attractive to measure the relative difficulty of various tasks by requiring a man to perform some other secondary task simultaneous with each of them. The secondary task might then be expected to show better performance when the main task is easier. Development of this technique has been widespread and moderately successful, the Unit taking a substantial part in the general effort (APU 509).

However, close analysis shows that the particular nature of two simultaneous tasks may affect the degree of interference between them. Two major points seem to be suggested by the evidence thus far: first, there does not appear to be much interference between simultaneous presentation of different stimuli as such, except when the two stimuli possess different verbal names well known to the man from his everyday experience. That is, the interference is rather at the level of the decision which categorizes the stimulus and selects an appropriate action, rather than the original intake of information (APU 747). Secondly, there may be interference between the execution of two motor acts; but perhaps less between the execution of one act and the decision whether or not to start the execution of another For example, prolonged car driving may make the driver's skill more "automatic", and thus impair a simultaneous motor task more but a decision task less; and distraction during driving may leave unaltered skill at passing through narrow gaps, but impair the decision whether or not to make the attempt (APU 772).

E. The Motor Control System

10. Keyboard Responses. In learning to execute a series of ungraded actions such as key-pressing, a substantial part of the difficulty has been shown to be the learning of the "reach" movement to find the appropriate key out of a set. Thus rapid learning may be secured by a chord keyboard in which the man executes two simultaneous finger-presses, one with each hand, to indicate one of twenty-five possibilities (APU 507). The processes of decision and execution are curiously interlinked however; many of a man's own errors

are immediately known to the man himself, can be corrected extremely rapidly, and must therefore in some way be checked or compared with a continuing decision process (APU 579).

11. Continuously Graded Responses. In making fine adjustments to control a car, aircraft, missile, or crane, it is equally true that training establishes a purely motor pattern of action which persists even if, for example, a new situation alters the position of the control so that the same muscular movement now shifts the lever in a new spatial direction. Similarly, a task which requires the same pattern of muscular movements is equally well performed when the object being controlled is seen only from a substantial distance; one cannot regard a human operator simply as a servo-system eliminating an angular error presented to the eye. Equally he is not a purely open-chain system which can be trained on a simulator to emit a series of movements, and produce them perfectly on the first trial in a real task (APU 639). In predicting the performance of human operators, one must therefore consider the kind of visual information available to the man, his previous knowledge of the statistical properties of the motion of the target, the extent to which he is making a gross movement to acquire a target or fine movements to hold it, and other similar factors, rather than merely treating the human operator as analogous to a simple servo linkage (APU 768).

F. The System as a Whole

12. Circadian Rhythm. A very laborious series of experiments has shown that many psychological functions (not all) show a circadian rhythm; that this persists in men living on a rapidly changing schedule such as the traditional Naval watch-routine; and that, when a sharp change is made to a 24-hr schedule different from the usual one performance adjusts to a new stable pattern very similar to the new rhythm of body temperature (which of course is not necessarily the same as the new rhythm of other physiological quantities). Close examination of the rhythms shows that, under normal conditions, it peaks surprisingly late in the day; and that the period of maximum efficiency is only 8-10 hours. Thus any schedule of life which has short watches separated by substantial rests, even if it allows sleep at the same time in every 24 hours, will tend to place one or other of the watch periods at a time when the man is awake but relatively inefficient. This is therefore an argument for rather long watch periods arranged in a stable pattern every 24 hours (APU 822).

13. Other Conditions of Work and the Interactions between them. Disturbances of circadian rhythm of ten involve sleep loss; and in that case the nature of the tasks most likely to show impairment has been examined in considerable detail. In almost a direct contradiction of Hughlings Jackson, complex and demanding intellectual tasks often show little effect, probably because the man mobilises effort to maintain performance even after 60 hours of sleeplessness. Prolonged and unstimulating tasks, however, form highly sensitive indicators; measuring instruments have now been devised with which it has even been possible to show effects of shortening the night's sleep rather than keeping a man awake all night. These tests have now also been used by at least ten other laboratories engaged in research on sleep, and have some claim to be standard tools. (APU 806).

Ever since it was demonstrated that sleeplessness and noise each tend to reduce the effect of the other condition, and that they interact in opposite directions with conditions such as high incentive or high rates of stimulation, it has been common to regard each condition as affecting a single general state of wakefulness or excitability. (Wilkinson 1963)*. This still seems well-founded; but it is increasingly clear that many complications must be added. A combination of alcohol with either sleeplessness or noise may produce unexpected effects; the impact of a raised environmental temperature may differ in different parts of the range, and will give different effects if the man's body temperature is forced to rise on the one hand, or if on the other he is allowed natural freedom to hold it as constant as possible. Some cautious broad conclusions are that "safe" levels of heat, noise, sleeplessness or other conditions may be roughly estimated; but that they can be exceeded without harming performance if other conditions are appropriate. Hence the need for sophisticated techniques to show the effects of these conditions (APU 759)

14. Ageing. One particular condition is worthy of special mention, because of the rather specific nature of the impairment produced. Although older people may be perfectly efficient at some tasks they show up badly at others. For example, the memory for a heard number of six digits may be unimpaired to an advanced age; and yet the ability to remember three digits and three letters, half presented to the eye and half to the ear, has been found to deteriorate by the age of 35. Equally, the effect of irrelevant visual stimuli surrounding a relevant one is greater in older people; and unlike the young they do not speed up as much when allowed to make the same response to any one of several signals, rather than choosing an appropriate specific response for each. Paradoxically, they may be better able to reverse a familiar sequence or rapid actions when something unusual happens, because they seem to make such a sequence as a set of separate responses to separate signals, rather than running off the whole sequence when they see the first signal. All these results and other similar ones can perhaps best be summarized by saying that the older person is impaired in his selection of relevant and rejection of irrelevant information; and much less so in many other functions (APU 647). The same may conceivably be true of the child: see III.3 below.

15. Physiological Indices. An increasing tendency throughout the period has been the simultaneous measurement of behavioural and physiological qualities. So far as the more peripheral measurements are concerned, the results have tended to change the interpretation of such measures. For example, muscle tension may rise when a man is sleepless, if he is highly motivated to succeed in his task; but if he is not, tension may not rise, and performance will then fall. Thus the muscle tension seems to reflect, not the central state caused by sleeplessness, but the amount of effort arising secondarily to keep performance constant. Equally, low heart rate may be associated with failures of signal detection in sleepless men; but not amongst those who have slept normally. At normal levels of alertness; therefore, failures of detection may arise from causes other than lowered arousal, a conclusion supported by other (purely behavioural) results.

Provided such limitations are remembered, measures such as heart rate, skin conductance, or muscle tension can provide useful supplementary information. Perhaps more hopeful at present however are measures based on the evoked response in the EEG, obtained by averaging the EEG following, say, 50 stimuli of a certain kind. Whatever the physiological basis of this response, the size of different components appears to be correlated with failures of detection under stimulating conditions on the one hand, and soporific ones on the other. It therefore offers some possibility of distinguishing failures attributable to different causes.

In fact, the magnitude of the contingent negative variation (CNV) under various conditions parallels quite well the efficiency of performance, where that performance can be supposed to be controlled by a stored probability, or expectancy, on the lines discussed earlier. (APU 786). On the other hand, there is some doubt whether the overall amplitude of the evoked response is changed by changes in the direction of the man's attention, as is often claimed. It is at least an open possibility at present that the evoked response is greater at times when a man is ready to act, rather than at other times; but not for stimuli from a sense organ which he is expecting to be stimulated, rather than for those from another sense. If this is confirmed by further work, it might mean that the evoked response was associated with arrival of information in the buffer store of Figure 1, rather than with the selective extraction of some of that information by the filter. (APU 804).

III. Future Plans

1. The Out-Stations. Dr. Colquhoun's work on circadian rhythm, together with his other interests in industrial inspection and vigilance, has recently been transferred to the University of Sussex. Although this work will still be part of the Unit's programme, it has been separately considered by Council when the out-station was set up and the plans will not be repeated in this report.
Similarly, Dr. Conrad's work on cognitive processes in deaf children, at the Nuffield Centre for Speech and Hearing, and that of Dr. Stephens and Miss Fuller on problems of psychoacoustics at the National Physical Laboratory, are normally reviewed separately; and are mentioned now only for completeness.

2. The Shaftesbury Road Group. Dr. R. T. Wilkinson's team, and Dr. Hartley, have recently been established in a separate house in Cambridge some distance from the main laboratory. These workers all make use of EEG averaging equipment, and have similar interests. In the next few years, Dr. Wilkinson plans to examine in more detail the effects on behaviour of deprivation of various stages of sleep: he already has behavioural evidence for different effects from loss of REM and of non-REM sleep, obtained without EEG backing. (APU 733). He will also, with the assistance of Mr. Adams, be developing suitable tests of performance for measuring effects of abnormal conditions in the field; this is an increasing area of demand. Dr. Hartley will be continuing with the work on evoked response and selective attention already mentioned, and studying the effects of various environmental conditions such as effects of noise, and the consequences of working for up to a week with very restricted sleeping hours.
The links between this group and others, and the interconnection of the latter, will become evident in later paragraphs.

3. The Main Laboratory: Skill and Ergonomics. Another group, of whom the most senior is Dr. Brown, will be examining problems of organization and of combination of tasks, with especial reference to car-driving. Two particular areas are being developed at present; first, the ability to resist distraction is being measured in children of various ages. There have been disturbing trends recently in accidents to younger victims, and there is tentative evidence that distractibility may still be present in children who have reached apparently adequate levels of mental function from other points of view. A second area is that of the visual perceptual problems of driving in fog, when disturbances of speed and distance judgement are easily produced.
Dr. Hunt, formerly of Hampstead, is examining the relation between heart rate, excretion of catecholamines, and driving; and in addition has observed changes in response to peripheral signals after prolonged driving on

one day, or after a number of days spent driving. Mr. Long is looking rather at the limitations on combining various kinds of task, which Dr. Brown's earlier work has shown to be important in driving. It is also ripe for closer theoretical study at present; the initial line is the use of simultaneous tasks of signal detection, using the parameters of statistical decision theory to analyse the results.

The practical applications of this group are, apart from those to car-driving, primarily to the Post Office. These outside contacts take a great deal of time, but their nature in future is hard to predict in detail.

4. The Main Laboratory: Displays and Controls. In this field, where many of the applications are military, Dr. Poulton and Dr. Hammerton are the most senior workers: with Mrs. Brand and Miss Woodhead concentrating more upon displays and Mr. McLeod upon controls.

On the display side, the main lines are (a) the study of visual search for relevant amongst irrelevant items, which is now of more practical importance than is signal detection. The particular problem under study is the effect of multi-dimensional signals in easing search, (b) further studies of combination of evidence in decision-making, both at the perceptual and at the intellectual level.

On the control side, the major problem under study at present is that of "cross-talk" when a vehicle under control is being observed from another vehicle which is itself moving. Control when vision is temporarily obscured is also being investigated. These problems are of course linked to that of the combination of tasks, (III.3), through the question of the autonomy of execution of motor acts. Similarly, the question of combination of evidence is also connected with that of distraction and concentration. (III.2 and 3).

Dr. Poulton and Dr. Hammerton also have interests in the effects of abnormal environments: at present further studies of the interaction of sleep and heat are in progress, and Dr. Hammerton is also mainly responsible for the project on minimal sleep mentioned in connection with Dr. Hartley. The tests used in both cases are linked to the work on division of attention and combination of evidence: and both factors are being included by Dr. Wilkinson in his development of portable tests for stress. (III.2).

5. The Main Laboratory: Comprehension and the Presentation of Complex Information. The most senior worker in this area is Dr. Morton, who is at present spending most time on problems of the interface between man and computer. In the specific project under way at this time, the difficulty is to arrange hospital records in a computer in such a way that persons whose skills are in areas other than programming (e.g. a nurse) can readily obtain the information they desire. This can be studied by comparing the ease with which untrained people can learn to use a large set of specific instructions on the one hand, or on the other a successive "conversational" process in which each step produces a small set of alternatives for the next step. At later stages of development, this work is likely to expand into the problem of the best general form of language for unskilled persons to use in interacting with computers.

This question is connected with that of comprehension of instructions in ordinary language by human beings. Dr. Wright has published several studies of the way in which particular syntactic constructions (especially active and passive sentences) affect memory, and she is continuing and extending this line. (APU 771).

Although complex information is so often delivered by language, there are also related problems which show up elsewhere. The interpretation of tables, for example; a function whose difficulty for ordinary people is often underestimated by scientists (APU 808). The presentation of route information to car-drivers is another.

In the latter case, Dr. Wright's area touches that of Dr. Holloway, whose main concern is with speech. That is, with language arriving to the ear, rather than visually, as Dr. Wright's stimuli usually do. Dr. Holloway is pursuing the changes which occur in conversation when very small degradations are produced in the quality of sound transmission between the parties. A particularly important aspect is the slowing-down of comprehension, which may become noticeable well before actual inaccuracy occurs. This in turn means that other jobs done during the conversation may deteriorate.

As the last point shows, this work is related to that on combination of tasks (III.3); and , through the question of context in speech to that of combination of evidence (III.4). Tests of syntactic comprehension are also used to assess the effects of stress (III.2), and the relative difficulty of different motor control systems (III.4). As opportunity permits, it is hoped to link physiological measurements to linguistic ones; some studies have been made of pupil size during sentence comprehension and a particularly fertile possibility is to take simultaneously measures of evoked response and of the intelligibility of particular classes of work (III.2).

6. General. It will be seen from the foregoing that the various lines of research are closely interdependent and that each tends to borrow from the others. At the same time the specialist in each area are few, and are hard-pressed by the number of enquiries, each in his own field. The newer lines of outside enquiry, in particular, can hardly therefore be met without dropping some of the older lines. Yet this would be damaging to the surviving projects. It is hoped therefore that, by some means, the total quantity of work in this general area can be increased in the near future.

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Appendix A

Outside relationships at one time in Autumn 1970

The following is a list of agencies with whom the Unit was in active contact in October-November 1970. By active contact is meant a degree of interaction amounting at least to advice on and provision of testing techniques, or detailed advice on procedure for tackling some problem. A number of other enquirers have been excluded who wanted only sets of references to the literature or a single letter of comment. Some of the agencies listed are of course sponsoring larger programmes of experimental work of long duration.

Atomic Energy Research Establishment

Army

British Aircraft Corporation

British European Airways

British Government Communication Centre

British Overseas Airways Corporation

British Standards Institution

Building Research Station

Council of Europe Working Party on International Standardization of Sanctions for Road Traffic Offences

Decimal Currency Board

Department of Psychological Medicine St. Bartholomew's Medical School

Food Manufacturers Federation

Gas Council

Home Office

Institute of Aviation Medicine Farnborough

International Association for Road Traffic Education

International Committee for Co-ordination of Telecommunication Facilities

International Drivers Behaviour Research Association

International Standards Association

John Lewis Partnership

London Transport

Medical Commission on Accident Prevention

Metal Box Co. Ltd.

Metropolitan Police

Ministry of Agriculture

Ministry of Health

Ministry of Technology Department of Trade and Industry

Ministry of Transport

National Environmental Research Council (British Antarctic Survey)

National Institute of Agricultural Engineering, Silsoe

Penguin Education Ltd

Psychological Institute of Free University of Berlin (for German telephone system)

Post Office

Road Research Laboratory

Royal Navy

Signals Research and Development Establishment

St. Dunstans

Swedish National Institute of Public Health (for sonic bag trials)

United Cambridge Hospitals

Wellcome Foundation

Other MRC Units

Air Pollution Unit

Dunn Nutritional Laboratory

National Institute for Medical Research

Appendix B

Membership of committees

Medical Research Council:

Environmental Medicine Sub-Committee

Erogonomics and Physical Environment Panel

Trawler Safety Working Party

Royal Naval Personnel Research Committee:

Main Committee

Hearing Sub-Committee

Working Party of Physical Fitness

Operational Efficiency Sub-Committee

OES Working party on "Human Factors for Designers of Naval Equipment"

OES Working Party on Sonar Problems

Army research Committee:

Working Party on Control Systems

Adverse Environment Sub-Committee

Flying Personnel Research Committee:

Main Committee

Otological Sub-Committee

Psychological Sub-Committee

British Broadcasting Corporation Science Consultative Group

International Committee for Co-ordination of Telecommunication Facililties

(CCITT) Working Party on Human Factors Problems in International Telecommunications

Medical Commission on Accident Prevention, Transport Committee

Ministry of Transport Research Committee on Road Safety

Post Office, Human Factors Research Committee

Social Science Research Council Psychology Committee

St. Dunstans Scientific Committee

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