CoA NOTE 148


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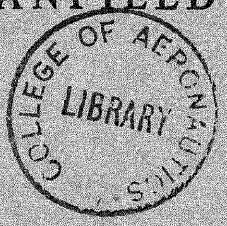


# THE ACQUISITION OF HIGH SPEED SKILLS

FIRST PROGRESS REPORT ON D.S.I.R. RESEARCH PROJECT

APRIL, 1963

by

D. Whitfield

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# The acquisition of high speed skills.

First progress report on D.S.I.R. research project

- by -

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## 1. Administration

Mr. D. Whitfield took up the post of Research Fellow in Ergonomics on 1st December, 1962. Mr. Whitfield read Experimental Psychology at Cambridge, and then went on to the Advanced Course in Occupational Psychology at Birkbeck College, London, where he was awarded an M.Sc. For the last two years he had worked in the Psychological Research Laboratory of EMI Electronics Ltd., on the ergonomics aspects of equipment design.

Mr. N.C. Mothersdale took up the post of Laboratory Engineer on 11th March, 1963. He has spent most of his working life in the Army and was demobilised last year with the rank of warrent officer, R.E.M.E.

Mr. Whitfield is at present dividing his time between a search of the relevant literature, the design of the main apparatus (in co-operation with Mr. D. McQue, a member of the College staff who specialises in instrumentation), and in visits to industrial organisations concerned with keyboard training. Mr. Mothersdale is constructing parts of the apparatus.

## 2. Background to the project

It is known that the human operator has various techniques by which he reduces the limitations on performance imposed by his reaction time. The development of these techniques, in particular situations, accounts for a large part of the learning process during which speed of performance increases.

At present, a gap needs to be filled by experiments on the extent to which sensory cues can precede relevant action and the way in which these phenomena change during learning. This can be measured in serial tasks either by stopping the input arbitrarily and noting how long the output continues, or, if related input and output are distinguishable on a time scale, the difference between them can be measured as the task proceeds. The latter approach is to be adopted to investigate the phenomenon of 'grouping', using the apparatus described below.

## 3. Progress of the project - two aspects

It is considered that the project has two aspects. First, there are the laboratory experiments to study some aspects of the development of skill in restricted situations. Second, there are industrial and commercial investigations, where the practical approach to training people in this type of skill can be studied. It is to be hoped, of course, that the laboratory experiments will eventually produce some recommendations for the design of training procedures, and so we shall try to preserve this dual aspect throughout the course of the project. Accordingly, we shall discuss progress to date under these two headings.

## 4. Progress in the laboratory

### 4.1 Experimental apparatus

The design of the experimental apparatus has been discussed in great detail, with special reference to our developing ideas of the particular aspects of skilled behaviour to be examined. The technical details are given more fully in the Appendix, but a brief description is appropriate here.

The subject's display will comprise eight electronic indicator tubes, allowing virtually instantaneous presentation of numbers of up to eight digits. The subject's control will be a ten-key keyboard, similar to those used in punched card operations, and his task is to enter the number, digit by digit, into the keyboard. The number can be displayed either until the keying is complete, or for a short, tachistoscopic, exposure. When the subject has finished keying, a new display will be presented. The apparatus will record the times between each presentation and the pressing of the various keys, and also the occurrence of any errors. Both the input to the apparatus (i.e. sequence of numbers) and the output (results) will be on punched paper tape, enabling efficient preparation and processing by digital computer. In particular, computer processing of the results will enable the maximum information to be obtained from this extremely detailed performance data.

'Knowledge of performance' can be manipulated by the experimenter, so that in case of error, a number can be re-presented, and also an aural or visual warning given. Overall 'knowledge of results' for any particular trial can be obtained from error and time counters in the apparatus. Particular care has been taken that even the most skilled subjects will not be restricted by the speed of operation of the apparatus, by allowing for a subject's maximum transmission speed of 10 digits per sec.



### 4.2 Experiments on 'grouping'

The first experiments will examine the effects on learning of the 'grouping' of digits. As we know, in a rather qualitative way, from studies of typewriting, the developing skill is manifested in such grouping of letters. Thus, learning may be assisted by external manipulation of this phenomenon at some stages. In particular, grouping can be imposed on some subjects by using the tachistoscopic facility of the apparatus.

In the first instance, it is proposed to put three suitably matched groups of subjects through different training procedures, and to compare the learning curves of the groups. Female subjects, corresponding to the level of ability of typical punched card operators, will be used, and the different procedures will be as follows:-

1. Presentation of one digit at a time, for the subject to press the appropriate key.

2. Presentation of groups of digits, for serial keying by the subject.

3. Tachistoscopic presentation of groups of digits, for serial keying. (This will force the subject to 'store' the group before beginning to key).

It is expected that the performance 'ceiling' (in terms of number of digits keyed per unit time) will be much higher in conditions (2) and (3) than in condition (1), and it will be interesting to see if there is any significant difference between the ceilings for (2) and (3). Of equal importance is the influence of the different conditions on rate of learning. Condition (3) may well produce the highest rate of learning, and would be expected to correspond with the later stages of condition (2), where we hypothesise that the subject will be dealing 'voluntarily' with whole groups at a time. Similarly, the comparison between developing rates of learning in conditions (1) and (2) will be of interest, indicative of any change from simple digit-by-digit processing to group processing. The interactions between the training procedures and the length of the groups of digits will also be examined, to test the possible scope of each method.

Another type of grouping is caused by the repeated occurrence of particular permutations of characters - for instance, the typist soon learns the familiar sequence 'th'. In later experiments, such effects will be examined by arranging for the input of number sequences to follow some definite pattern; the effects of varying probabilities of permutations can then be observed.

By studying the relationships between such grouping and learning, we may be able to suggest some methods of speeding up the learning process. In fact, this approach to the subject's 'organisation' of the material for his task may answer some of the criticisms which have been made of current attempts to automate the teaching of these skills (see below). For instance, it has been suggested that SAKI teaches only the basic layout of the keyboard and does not cover the other half of training - i.e. document layouts and coding procedures.

### 4.3 Modes of feedback

A separate area of interest is the feedback channels used by the operator to control his performance. We know - again, in a qualitative way - that a manual skill is often characterised by increasing reliance on kinaesthetic rather than visual cues. Indeed, training in typing and card punching is directed towards acquiring such a skill. We shall be able to examine the effects of enforcing this reliance on

kinaesthetic cues at various stages. The possibility of supplying feedback in other modes could be examined also; two suggestions are aural (speech) indication of the digit keyed, and tactile coding of the surface of the keys.

### 4.4 Keyboard and display design

The consideration of feedback channels leads us to the possibility of using the apparatus to evaluate keyboard layouts; the present design does, in fact, allow for attaching different keyboards, and hence measuring their effects on operator performance. One aspect of design seems very worthy of investigation. It has been pointed out that most of the studies of key and keyboard design have allowed the subjects to employ visual cues in selecting the keys. The optimum design parameters for 'touch' operation may well be different.

The apparatus can be used similarly to study the influence of different methods of presenting material to the subject, by changing the design of the display.

### 4.5 Conclusion - areas of immediate concern

It is felt, however, that the investigation of the acquisition of skill deserves a higher priority than equipment design problems, mainly because comparatively little work has been done on the former. In addition, most aspects of keyboard design, except for the 'touch' characteristics, seem to have been covered quite comprehensively. An intensive search of the literature is thus necessary before embarking on any specific proposals, and this is being undertaken.

## 5. Progress in practical investigations

Discussions of training methods for card punch operators have been held with IBM and ICT, and for stenotype operators with the Palantype Organisation. At this stage, our aim has been merely to build up a broad picture of the current practical approaches to these problems.

In general, it seems that the approaches, if uninspired, are sensible. Exercises of gradually increasing difficulty are used to promote mastery of the keyboard, and then speed is built up by prolonged practice. The stenotype operator is, of course, a special case, taking up to a year to gain acceptable speeds, but card punch operators are generally held to have finished their formal training after two weeks. What is not at all certain is how much more 'hidden' training goes on before they achieve the norms of production work. It would certainly be useful to have some indication of these norms, both to compare against the immediate graduates of training schools and against our subjects in the laboratory. Some 'shop-floor' recording technique could supply data on production and training school performance; an attempt to discover some production norms is also being made in a

questionnaire on training which is being circulated to supervisors of IBM service bureaus.

Much interest, of course, centres around SAKI, the card punching teaching machine. The general opinion seems to be that it does teach mastery of the keyboard (though there is no sound evidence of this), but gives no assistance on the 'perceptual organisation' side of the operator's task. As discussed above, our own apparatus will make good part of this omission. Moreover, our own assessment of SAKI is that it has been designed with regard to a hypothetical model of the learning process; it seems reasonable first of all to observe the learning process in detail, and then to devise a training technique to match that process. SAKI's neglect of grouping would seem to be a sympton of this failing.

We thus have the potentiality for extending training techniques to cover some part of the perceptual organisation of the operator's material. What type of benefit seems most likely from applying any of our findings in practical situations, in particular in the card-punching area? In general, training schemes may increase productivity, reduce training time, or reduce the required capacity of operators. As discussed above, it seems most likely that the present acceptance of a two week training period conceals some 'hidden' training which takes place in the succeeding production situation. Our major aim therefore must be to reach the productivity ceiling earlier - this requires, of course, some practical measurements of what the ceiling is. As for raising the ceiling itself, the same measurements will give some indication of the possibilities here - though it appears that there is little room for improvement in this relatively simple skill. The conclusion that this is a relatively simple skill has suggested that it might be worthwhile examining more complex keyboard skills, such as typewriting and comptometer operations, to find wider outlets for the results of the laboratory experiments.

## Appendix - Description of the apparatus

### Operational specification

The apparatus is to comprise, so far as the human subject is concerned, a display and a keyboard. The display is to be capable of presenting decimal numbers of up to eight digits. The keyboard is to have ten keys, one for each decimal character. A programme of decimal numbers will be presented, all digits simultaneously; the subject is required to reproduce the digits serially on the keyboard. The duration of each presentation is either for a preset time, or until the subject successfully copies the number displayed.

The following results are required:

1. The time between presentation and the pressing of each key.

2. The decimal character to which the time is related.

When the subject makes an error, this is to be noted and the display is to be temporarily blacked out and a warning note sounded or a lamp flashed. Either the same number will be repeated or the next presented to the subject. These conditions are to be under the control of the experimenter.

Every time the subject completes a number, the next number is to be presented with a minimum of delay, preferably less than 10 millisecs. The input programme can consist of about 500 numbers of up to eight digits. The subject's display will have easily read numbers about 1 inch high, and his control will be similar to the keyboard of a card-punching machine. The whole system is to be capable of dealing with the expected maximum speed of the subject's response; the available evidence suggests that 10 key depressions per sec. will be a realistic ceiling.



To avoid excessive labour in the production of the input programme and in the reduction of output data, it is desirable that these be done by the Pegasus computer, which may be arranged to generate random or patterned input programmes as required for input, and just as easily rearranged for output data analysis.

The input programmes can therefore consist of rolls of 5 level punched paper tape i.e. the normal output from Pegasus or manually prepared tapes.

The output programmes can also be on 5 level paper tape for entry to Pegasus or a teleprinter.

Technical specification

Input: A tape reader capable of reading at a speed of at least that of the subject if the numbers are all to be of the same length, and in the ratio of the longest to the shortest, at least, for random length numbers. Thus a speed of 20 char/sec. is desirable for numbers of uniform length, and 100 - 150 char/sec. for 1 to 8 character numbers, when allowance is made for spacing characters. For uniform length numbers a Creed mechanical tape reader is adequate, whilst to meet the non-uniform length requirement, a faster and more expensive reader will be required.

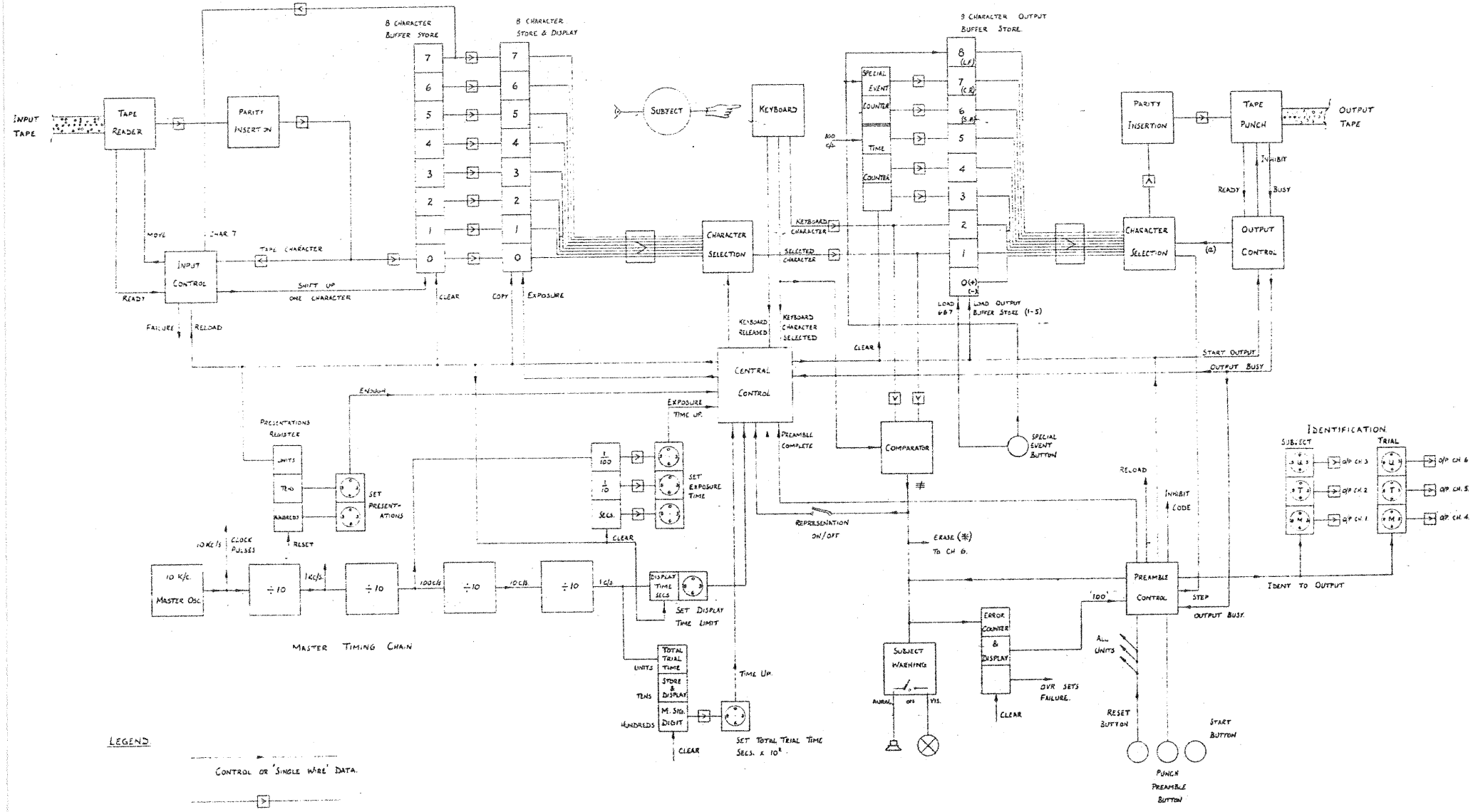
Output: A Westrex high speed punch, operating at 110 characters per sec., is needed to cope with all the output data at the above-mentioned speed of operation.

Display: Mullard Z520 M Digitron tubes. Future experiments may require filament lamp in-line displays; the system is to be compatible with these.

Control system: A system using diode/transistor NOR logical elements is to be used. The various circuit elements are assembled on 24 way 0.15 inch spacing 'Veroboard cards' having gold plated termination for insertion into 24 way connectors.

Progress to date

An overall block diagram of the apparatus has been constructed and agreed, and is reproduced on the following page. This has been correlated with a provisional design for the experimenter's control panel, evolved from a systematic study of the required facilities. The detailed logical design of the input control unit is complete, and work has begun on the remainder. The basic plug-in cards have been designed and are being constructed. A programme for generating input tapes on Pegasus has been devised.




# High Speed Skills Apparatus - System Block Diagram