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USE OF A TEACHING MACHINE IN MEDICAL EDUCATION; PRELIMINARY EXPERIENCE WITH A PROGRAMME IN ELECTROCARDIOGRAPHY

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THE principles of 'programmed learning' and their possible application in the field of medical education have recently been reviewed by Green and Weiss (1963). Though teaching machines are gaining increasing acceptance in many branches of elementary education, their practicability and effectiveness largely remain to be determined at the University level in general and in medical teaching in particular. In view of the interest in such methods now being evinced by medical educationalists, two of us (S.G.O. and R.H.) have embarked on a controlled trial among final year medical students which aims at comparing machine-teaching of electrocardiography with the conventional techniques of personal instruction and private reading.

It is not possible for us to anticipate the eventual results of this trial, which will not be known for some time. The notes which follow are based on our preliminary experience with the method and on the subjective reactions of a small number of students on whom the ECG programme was 'validated'—i.e. tested-out prior to final revision.

They are presented in the hope that other medical teachers may feel it worth while to write programmes in their own subjects and so to allow a more general assessment of the value of programmed learning.

What is Programmed Learning?

The British Medical Journal (1963) has defined the distinctive feature of a programme as 'the use of an appropriate learning sequence which permits of the logical development of a subject, explanation of incorrect answers and repetition of important basic features'. In a 'linear' programme this learning sequence is pre-determined and fixed, a method which is generally held to be more appropriate to elementary education than to the relatively complex subjects with which medical teaching is mostly concerned. The other type of programme is 'branching', in which the learning sequence is not unique. Here it is the student's own response, usually to a multiple-choice question, which determines the next piece of information to be presented to him. This arrangement

FIG. 1.—Extract from flow-diagram of ECG programme.

FIG. 2.—Grundytutor teaching machine.

permits a considerable degree of sophistication in programming, making it possible to ensure that a particular point has been learnt or understood before a student is allowed to proceed further. Otherwise, appropriate remedial material is presented to him, usually in the shape of additional explanation or revision of earlier facts or principles. Such material, which may incorporate its own tests and subsequences, is normally followed by re-testing before the student is allowed to re-join the main learning sequence and carry on with the course. Fig. 1 shows a short extract from the flow-diagram of our ECG programme, which employs the branching technique, to illustrate this type of arrangement. The method has many advantages, not the least of which is economy of the student's time; only those who need the additional material are required to go through it and each, therefore, proceeds at his or her own correct learning pace.

It is possible to present a branching programme as a series of cards or as a 'scrambled' textbook,

but we have found it more convenient to use one of the teaching-machines which have recently been devised for the purpose.

The Teaching Machine

The Grundytutor teaching machine which we are employing, is shown in Fig. 2. The programme is filmed on 35 mm. film and is presented on the screen by means of a back projection system. A set of eleven buttons situated below the screen enables the student to move from one frame on to any of ten new frames, or to return to the frame he last saw. This means that in the multiple-choice situation the programmer can, if he wishes, use as many as ten alternative answers; nine of these would take the student to remedial material, consisting of either a single frame or a more extended subsequence, and the correct answer would produce the next frame of information. Each button causes the film to be transported forwards or backwards a fixed number of frames, so the order in which the student views the frames is

not the same as that in which they appear on the film.

The Programme

Since no suitable programme in a medical subject was known to us at the time (February, 1963) when our study was first projected, it was necessary to write one. Electrocardiography was chosen partly because of the special interest of one of us (S.G.O.) but also because it seemed appropriate on other grounds. It can be taught as an intrinsically logical and self-contained subject and hence lends itself to the programming method. Furthermore, final year medical students at the University of Newcastle can be expected to have little or no fore-knowledge of electrocardiography and, therefore, constitute an ideal population on which to carry out the controlled trial we envisaged.

In its final version*, the programme consists of 604 pages or 'frames', 254 of which represent the main learning sequence. The remainder comprises remedial material, both as single 'wrong-answer' frames and as more complicated sub-sequences and revision loops. An appendix to the programme provides a number of electrocardiograms for practice in ECG interpretation. Most of the main-sequence frames pose a multiple-choice question, the student's response to which determines his route from that point. Two typical frames from the main sequence are reproduced in Fig. 3 in order to illustrate the manner of presentation. A few constructional problems are also given at points where they seem appropriate, the student comparing his own answer with one which appears on the subsequent main-sequence frame. Our programme to some extent, therefore, employs the 'linear' as well as the 'branching' technique.

Validation of the programme

As the British Medical Journal (1963) has pointed out, one of the significant features about a learning programme is the care which goes into its preparation. This normally includes the process of 'validation', which consists of testing out a provisional version of the programme on a number of the target population. A record is kept of the average time spent on each unit of the programme, of the frequency of correct and incorrect responses to the multiple-choice situations and of any comments made by the students themselves on the material presented. In the light of the information so obtained, the main sequence is re-written and the remedial material is related in amount and content to the actual frequency of errors.

* Now published as 'Principles of Electrocardiography' by S. G. Owen, International Tutor Machines Ltd., Ashford, Middlesex.

In the present study, the programme was validated on twelve final-year medical students. Four machines were employed, these being worked on an appointment system continuously throughout the day. The average time taken by the students to go through the programme was 15 hours and the whole procedure took a little over a week to complete.

The programme was then revised in accordance with the validation findings. To some extent revision consisted merely in adjusting the size of the information units, but much re-writing was also found to be necessary. To give one example, it was revealed that the majority of students were failing to understand the genesis of the abnormal ECG patterns in bundle branch block. After careful consideration of their comments, a fresh approach to this subject was adopted which we believe represents a considerable improvement in our teaching technique. Validation proved to be a salutary experience for us as teachers in addition to fulfilling its primary aim of making the programme effective and efficient.

Students' reactions

The twelve students who assisted in validation were subsequently invited to complete a questionnaire designed to assess their reaction to this method of learning. All twelve stated that they had enjoyed taking the course, and eleven felt that programmed learning had a definite future role in medical education. Several of these added that they thought that its place would be limited and that personal teaching could never be wholly replaced except perhaps in one or two subjects.

Eleven also said that they would like to have other subjects made available to them in the same form. Those most frequently mentioned were acid-base balance, renal physiology, kidney diseases, metabolic disorders and endocrinology. Other suggestions included heart sounds, neurology, differential diagnosis, correlation of physical signs with pathology and interpretation of physical findings in the chest. One student felt that any subject with a physiological basis demanding understanding as opposed to mere memory would be suitable for programming.

Six of the students considered that they could concentrate better on the machine than on a text book, though one of these felt that this was due to the way the programme was arranged rather than to any quality inherent in the machine itself. He suggested that if the programme could be presented in book form it would be just as good. Four of the remaining six thought they concentrated less well chiefly because of the distractions of three other machines working in the same room.

II, III and VF was the correct answer. These leads are often loosely referred to as "posterior" leads because they tend to reflect the back of the heart. The clue of course is in the fact that the posterior surface really faces in the posteroinferior direction. The conventional 12-lead ECG does not include any strictly posterior electrode (e. g. one on the back of the chest), but reference to your hexaxial diagram will remind you that it does include three INFERIOR leads, namely II, III and VF, all of which have a connection to the foot.

If the changes due to right coronary occlusion extend round to the lateral chest leads, i. e. V6 or V5 and 6, as they occasionally do, the ECG designation is POSTEROLATERAL; otherwise the infarction is simply termed POSTERIOR.

Examine the ECG below. It was taken from a patient who presented with the clinical syndrome of acute myocardial infarction. Does the tracing confirm the diagnosis and, if you think it does, which coronary artery do you suspect has been occluded?

diagnosis not confirmed

left main trunk occluded

left anterior descending a. occluded

left circumflex a. occluded

right main trunk occluded

FIG. 3 (a).—Main sequence frame.

Yes; the left anterior descending artery was occluded. This is the typical picture of acute antero-septal infarction. Another example is shown in tracing 1. on the right. As in the previous record, the changes are maximal in V2-4, the septal leads, and comprise deep, wide pathological Q waves, absence of R waves and marked S-T elevation. The area affected approximates to the distribution of the anterior descending branch of the left coronary artery.

Time relationships are important. The signs of infarction take a few hours to develop, so that an ECG taken immediately after the onset of symptoms may fail to reveal them. The first obvious abnormality is S-T elevation, followed shortly afterwards by lowering of R and development of Q over the infarcted area.

S-T elevation usually subsides within a day or two. As it does so, T wave inversion, hitherto partially masked by the high S-T

segment, becomes more pronounced and takes on the deep symmetrical negativity referred to earlier in the course. Compare the two sets of chest leads on the right. 1 was taken eight hours after coronary occlusion, 2 a week later from the same patient. In 2 the S-T elevation has almost disappeared and the characteristic T wave pattern is now seen.

The left-hand tracing is from another patient, who three months previously had made a complete clinical recovery from a heart attack.

From the limb leads shown, can you decide whether the infarction was anterior or posterior?

	Press
Anterior	A
Posterior	B

FIG. 3 (b).—Main sequence frame.

and of the frequent visitors who came to watch them.

On the whole, we thought the general reaction of the students was very encouraging, particularly in view of the facts that there were a number of faults in the validation copy of the programme and that the necessity for recording all responses makes validation a very much more tedious process than working through a finished programme.

We made no serious attempt to assess the teaching efficacy of the method at this stage, the primary object of which was to produce a programme for use in our subsequent definitive experiment. But the results of a short objective test in ECG

interpretation which each student took after completing the validation course suggest that it is likely to be very effective indeed.

Conclusions

At present, conclusions can only be provisional. But on the basis of our experience so far we feel justified in our view that programmed learning is likely to become at least a useful ancillary method in medical education. It is to be hoped that other trials than our own will be undertaken in order to allow the value of the technique to be more generally defined.

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