A METHOD FOR THE STUDY OF WRITTEN SPEECH

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Written speech is of considerable general physiological interest as a process of extremely delicate and highly perfected coordination of movements, a highly perfected motor skill. It has occupied the minds of specialists in forensic medicine [1], school health [2], neurology and psychiatry [3] and, more recently, engineers and mathematicians, working in the field of form recognition [4]. The features of handwriting are known to be quite constant, and that changes in the writing of letters and words are only seen when there are serious abnormalities in the functional state of the brain, as, for instance, when there is involvement of the temporal region. This does not mean, however, that written speech is a completely automatic act, the disturbance of which requires fairly violent disturbances in the human organism, and particularly in the central nervous system. The study of written speech has hitherto been confined to examination of the end results—the handwriting, the formation of letters and words. There has been little research on the actual process of writing.

This papers describes a new method for the study of written speech - graphometry, a method providing objective data on the process of writing, the movement parameters of the writing instrument (pencil) in the writing of certain prescribed written signs. The method is based on the examination of oscillograms produced by the motor acts associatedwith writing. The amplitude and time characteristics of the recording depend, not on the symbol written, but on the manner in which it is written; the indices are the speed and direction of the pencil movements, the time taken to complete individual movement cycles, and the manner in which these follow one another.

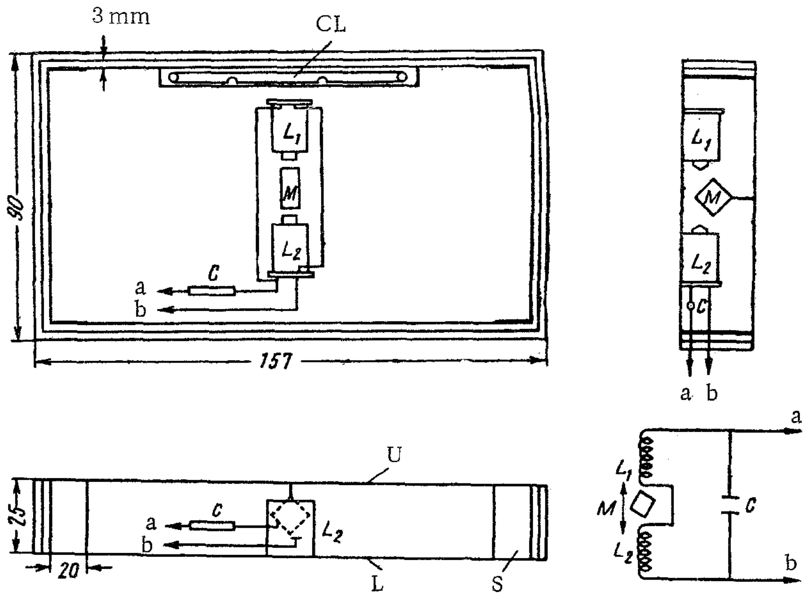

Fig. 1. Diagrams of apparatus for examination of writing. U) Upper plate. L) lower plate. M) magnet. L_1, L_2) induction coils. CL) clip for fixing paper. S) spring. C) condenser. a, b) to terminals.

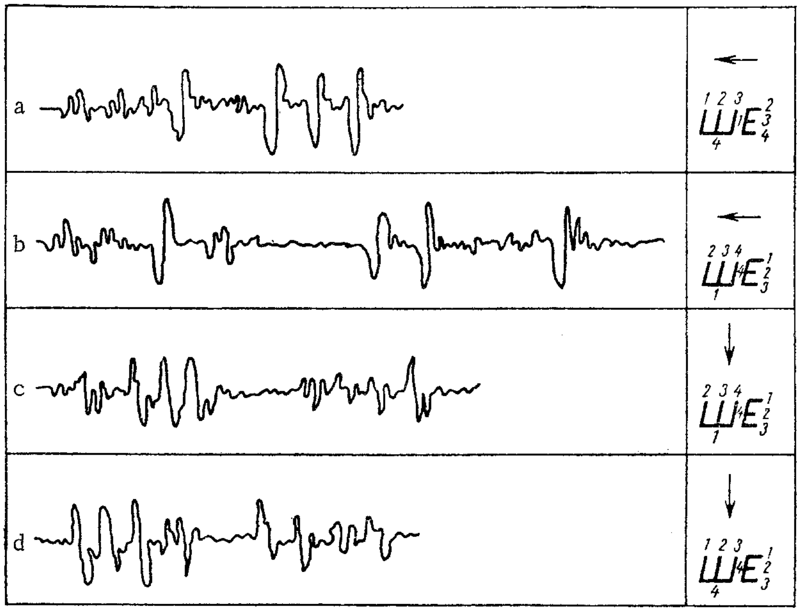

Fig. 2. Oscillograms of letters and produced by vertical (a, b) and horizontal (c, d) displacement of the upper plate. Explanation in text.

The apparatus used for the study of writing movements (Fig. 1) consists of two metal (or plastic) plates, firmly connected together by four flat organic glass spring elements. Displacement of one plate in relation to the other is only possible in the direction perpendicular to the plane of the springs. Inside the apparatus there is a constant magnet and induction coils attached to the opposing surfaces in such a way that, when (with the plates) the coils are displaced in relation to one another, the induction current produced by the coil is maximum. A capacitance of the order of 5-10 mF is connected parallel to the coil to obviate various mechanical and electrical forms of interference. When a sheet of paper is placed on the upper plate and a letter or figure is written on it, the movements of the pencil will be transmitted to the plate and cause its displacement. Consequently, there is development of induction current in the coil proportional to the speed of the pencil movement and the sine of the angle between the direction of displacement of the plate and the direction of pencil movement. The signal put out by the apparatus will be maximum when these directions are coincident. As the maximum output voltage does not exceed 0.5-1.0 mV, an electrocardiograph is used to record the signals. For easier working, paper prepared in the form of slips 150 × 80 mm (the measurements of the upper plate) is clipped to the upper surface.

The oscillograms of written symbols obtained with this apparatus can be analyzed for parameters of movement of the writing instrument (pencil). The elements of letters and words, coinciding in direction with the axis of recording produce oscillographic movements of greater amplitude than elements perpendicular to this axis. Oscillograms for the letters and, written first from above downwards and then from right to left, are shown in Fig. 2. The elements of the letters running parallel to the recording axis are of large amplitude, and those at right angles to this axis, small. Each letter consists of four elements, and the numbers on the right indicate the order in which the elements have been written. In the case of the first letter, for example, the three vertical lines were written first, and then the horizontal stroke. This order can be recognized from the recording by study of the alternation of large and small waves. The times taken to write each letter and each element can also be analyzed. The different times taken to write the same two letters are illustrated in Fig. 2a and b. In this case the difference can be ascribed to the intervals between the letters and between their elements. In other cases the writing time is reduced. This is readily determined from reduction of oscillogram amplitude with simultaneous increases in the times taken to write the elements.

The motor acts can be analyzed in detail in respect of amplitude and time by this method. Analysis of the oscillogram for the figure 6 will illustrate this (Fig. 3). The segments of the oscillogram are numbered and the turning points are lettered; each turning point corresponds to the point when the pencil movement changes from one to the opposite direction (upwards to downwards, or vice versa). Each segment corresponds to the movement of the

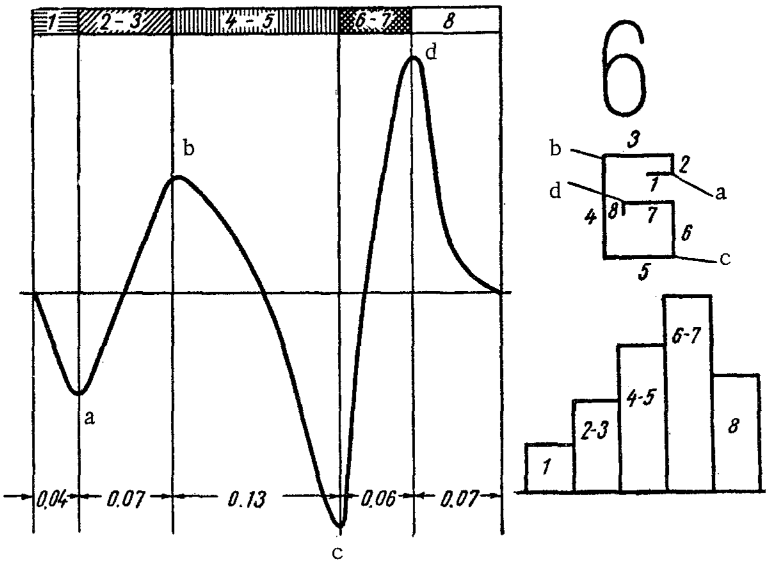

Fig. 3. Analysis of the oscillogram for the figure 6. Explanation in the text.

pencil in the one general direction, not deviating by more than 180° from the axis of the displacement of the plate. A diagram of the motor act in writing the figure 6 is shown in Fig. 3 (center, right), with the elements denoted by numbers, and the movements of change in movement direction denoted by letters. Analysis of the oscillograms in respect of time and amplitude provides data on the times taken to complete the individual elements of the symbol and the speed of pencil movement in each stage. These data are shown schematically in Fig. 3 (below, left) in the form of a detailed time schedule of the motor act and (below, right) a diagram depicting the relative speeds of movement in each stage.

These results indicate that the motor act involved in writing can, be this method, be analyzed objectively, in respect to the times taken to write a symbol and its individual elements, the speeds of the individual movements, their directions, and the order in which the elements are written.

This very simple form of the apparatus described obviously cannot reveal all the possibilities of the method. The author is of the opinion that the vector principle, with movements recorded in three axes, might be incorporated with great advantage. It is very probable that the form and area of the vector loops, together with the directions of movement of the vectors for each element would provide more extensive information on the motor act and might reveal the finer mechanisms of movement coordination.

The main advantage of the method is that it provides a means for quantitative definition of the motor acts involved in writing. With development of computer technique, it will not be difficult to create logarithms for analysis of the oscillograms for different and even complex motor acts, and to evaluate the processes of written speech while it is being produced. All that is required for automation of the process is the collection of suitable experimental data. It is thought that the method is a promising one for the study of writing both for research purposes and in connection with diagnosis and expert evidence.

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