The Place of Electromyography in Speech Research

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Reproduced from *Behavioural Technology*, No. 6 (1971).

Electromyography (EMG) is now an established technique in research into human speech production. The bulk of the interesting work in phonetics today centres around the developing of a viable speech production model and EMG is providing valuable information in this area. The model treats the process of deriving the soundwaves of speech from the higher-level phonology,* [*footnote: Phonology is that part of the grammar we all possess of our own languages which systematically determines the patterns of sounds required for producing a meaningful utterance.] and speech production itself can be regarded as the correct organisation of the musculature controlling the organs of speech to enable the correct sounds to occur at the correct time (as dictated by the phonology). This involves setting up the speech articulators in such a way that particular aerodynamic effects occur to produce sounds according to certain laws of acoustics. The speaker does not have the power to invent the rules of acoustics and aerodynamics, of course — but he must in a sense discover and remember what they are in order to be able to use them for speaking.

EMG is a technique which enables the experimental phonetician to take a look at the muscular contractions involved in creating particular vocal tract configurations to enable the acoustic effects to take place. What EMG is, and the simple apparatus required in speech research have been described elsewhere [Fromkin, 1965; Fromkin and Ladefoged, 1966; Harris *et al*., 1964; Lysaught *et al*., 1961], but briefly the idea is to detect, amplify and display the minute electrical potentials generated when muscle fibres fire or contract. Clinical EMG is often concerned with the details of the form or waveshape of the firing of a single motor unit — it is possible to make certain types of diagnosis from such evidence — but in speech this is not our concern. Generally the researcher here is concerned with such matters as the overall duration of contraction of the muscle as a whole and when in time it starts and stops contracting (relative to other muscles involved or the resultant soundwave) [Tatham, 1970], how ‘intense’ the contraction becomes [Fromkin, 1966; Tatham and Morton, 1969] — and how quickly this peak of intensity is reached and how quickly it diminishes, at what point in time the contraction intensity is most crucial and under most accurate control [Tatham *forthcoming*], and so on.

Recent research has split into two types with respect to technique: one involves the use of needle or similar electrodes implanted in the muscle, and the other the use of surface electrodes placed on the skin over the muscle. Aside from the technical fact that most speech muscles are directly accessible to needle electrodes while the use of surface electrodes is restricted to those muscles lying immediately below the surface of the skin and runs the risk of picking up unwanted signals from adjacent muscles, there is no general agreement as to which technique ‘best’ when either may be used. The work in my own laboratory is concerned with examining the behaviour of the muscle as whole and so we tend to use surface techniques whenever possible — needle electrodes often present a local picture which may or may not reflect the behaviour of the entire muscle (particularly when attempting to examine the precise timing of a contraction). Needle techniques, however, do usually give an unequivocal indication of whether or not a particular muscle is involved in a particular articulatory gesture It is very much a question of choosing the right technique for the job at hand.

Typically the resultant EMG signals are processed (particularly and most meaningfully from surface electrodes) to provide a transformed signal indicative of the amplitude of the EMG waveform. This processing and subsequent measurements are usually performed by computer [Music *et al*., 1965; Morton, 1969] to handle large quantities of data. There is a very simple reason for this: considerable variation occurs in the EMG of linguistically same utterances [Mansell, 1970]. Thus a particular speaker simply repeating the same utterance over and over will typically not produce identical EMG signals. The solution to this problem rests in the adequate statistical treatment of data from a set of just such repeated same utterances. Thus it is possible to observe trends and establish probabilities for the behaviour of speech muscles for a given phonological utterance from EMG records.

Such observations, whilst important in themselves, are comparatively uninteresting unless they contribute to the overall model of speech production. Apart from the rather trivial establishing of which muscles are involved in which gestures EMG has been able to contribute considerably (in my view) to our understanding of speech production. While speech researchers still do not entirely understand EMG signals or their correct interpretation a number of important discoveries have been made with the technique and its development is not faltering.

Perhaps one of the most interesting areas of study concerns the degree to which speakers are concerned with the precision of a particular articulation. Analyses of the variations mentioned above may tend to indicate that careful consideration is given to the precise positioning of the speech organs in one case, but not necessarily in another. In addition, studies are beginning to reveal the importance of regarding the allophonic variations of phonologically same segments or sounds as comprising two sets: that of controlled and that of uncontrolled allophones [Tatham, 1969,1971]. There is apparently an interplay between these two sets. One occurs at one level (of neuromuscular control) and the other at another, distinct level (of lack of infinite elasticity in the whole system of vocal organs and their control mechanism). Some evidence from speech production, using EMG, is being adduced in favour of a relatively simple phonology and a relatively complex phonetics hopefully eventually demolishing the 'context-sensitive' theory of allophonic variation which implies a system of contextually encoded segments in the phonology.

Thus we are beginning to see the technique of the EMG being developed in speech research as a refinement more general kinesiological studies and existing quite apart from the micro-use in clinical diagnosis of muscular or nervous disorders. It may well be that adequate development of the techniques or interpretation of the signals will result in much better understanding of the speech production process than we have at the present time.

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