

## CENTRALIST AND PERIPHERALIST ORIENTATION IN MODELS OF SPEECH PRODUCTION

PHILIP MANSELL

The control of the extent, sequencing, and coordination of speech movements is a central problem for models of speech production. It is furthermore an extremely complex problem which may not be amenable to modelling in terms of one single type of control system. Indeed, the purpose of this paper is to suggest that, whereas there exists at present a *de facto* controversy between what I am calling CENTRALIST and PERIPHERALIST models of the control of speech, yet in fact the two systems should be thought of as complementary rather than antagonistic. It will be argued that to concentrate on peripheral mechanisms on the grounds that a peripheralist account would be inherently more parsimonious is mistaken. Examples where a measure of central planning is apparently required will be given, and it will finally be suggested that admitting centralist planning into a model of speech production gives us greater freedom in the construction of models of language behaviour as a whole.

First, however, it is necessary to look briefly at some of the possibilities that exist for the control of speech. I want to suppose a speech production model which consists of three components in series. The most central of these components is a phonological processor. This is followed by a processor, termed a motor command generator, which converts the linguistic units of the phonology into motor commands. These commands form the input to a motor system, the output of which will be articulatory movements. Contained in the motor system box will be a description of the inevitable neural and mechanical constraints which will affect the outcome of commands processed through that system. I want to further assume that at the most peripheral end of the motor system, there are sensory devices capable of providing ongoing information about the movements resulting from the processing of motor commands through that system. It is not necessary for the purposes of this paper to specify the nature of these peripheral devices.

Now, various possibilities exist for making use of the information that these devices automatically provide. In the first place, feedback loops operating completely within the motor system have been suggested for the automatic modification of motor commands within the time-span of a movement. This system is concerned with the

control of the extent of movements on one articulatory parameter. Secondly, if the feedback information is projected beyond the motor system, closed loop and serial chaining models can be considered. The first is again concerned with the control of the extent of movement, but is possibly too slow to effect changes within a movement. The second claims that feedback relating to the successful completion of one movement can trigger the release of commands relating to a subsequent movement along the same articulatory parameter.

These systems form, generally speaking, the basis for a peripheralist account of control. What they have in common is that they do not allow predictive power to the motor command generator. That is to say, they implicitly disallow the possibility that the motor command generator might contain a model of the effects of the motor system, such that the generator in issuing its commands has already taken into account the results of processing those commands through a motor system. It is this predictive power which distinguishes an account which admits elements of a centralist explanation, and it is this power that I am suggesting should be incorporated in a model of speech production. It should be noted that the claim refers only to the possession of predictive power by the centre, as represented by the motor command generator. No claims are made (or necessitated) about the precise effects on the nature of the commands issued. Thus it is not a necessary part of this model, as it is with certain centralist accounts, to claim that these commands are context-sensitive along the time dimension.

One immediate result of admitting predictive power to the motor command generator is interesting because it illustrates the complementary roles which centralist and peripheralist mechanisms might play in the control of speech. For maintaining that a motor command generator can predict the outcome of a particular motor command is equivalent to supposing that it can predict the peripheral feedback to be expected as a result of the issue of that command. Under such a system, feedback at the motor command generator level would always be correct, except in unusual circumstances. And this result provides a prerequisite for the peripheralist serial chaining hypothesis, which otherwise is seriously embarrassed by the amount of feedback which, in the absence of a motor command generator with predictive power, will inevitably be signalling failure.

Models with centralist orientation, then, need not be construed as denying the relevance of peripheral mechanisms. But it is perhaps a different argument that has by and large kept peripheralist models in the forefront of experimental work, at least, in phonetics. This is the assumption that a wholly peripheralist account of speech production is, on *a priori* grounds, the most parsimonious one, demanding thereby to be investigated experimentally as a first priority. Maintaining this presupposes that we have either an independent criterion of parsimony, or that a criterion has been derived from an adequate analysis of the physical system to be modelled. I would suggest, first, that we possess no adequate independent criterion, and secondly that we do not have at present a clear account of the system to be modelled from which

to derive a criterion. To mention only one relatively unexplored area, the VARIETY of types of speech movements is not often discussed, nor are the different problems associated with the various phases of individual movements. An exception here is a recent paper by Haggard (1971) where two types of control system are suggested for speech movements, one (central) for the initiation of movements and another (peripheral) for their conclusion.

Two areas where it seems likely that phenomena will be encountered which require the particular virtues of a centralist account (again possibly in conjunction with peripheral mechanisms) will be mentioned. The first case is straightforward. For the coordination of movements along a number of different articulatory parameters simultaneously, it would seem that central planning is required. If feedback information played a part here, as it might, then we should have to require that the centre predict not only the nature of the feedback but its timing as well. The position can be stated thus baldly since research has shown very little evidence for the possibility of the triggering of movements on one articulatory parameter by events along a different parameter.

The second example is more complex. The subject matter is the variations encountered in speech as a result of non-linguistic environmental factors. Take the case of articulatory variations induced by changes in speech rate. Now, in a three-component model such as the one described here, it seems implausible to list or generate all such variations in a phonology. And the complexity of the variations might be sufficient to make us reject a model where, commands from the command generator being identical in all cases, although issued at a different rate, all the variation was attributed to the motor system. The alternative is to have the motor command generator perform computations in order to output different motor specifications dependent upon the speech rate and dependent upon the linguistic structure of the utterance signalled by the precedent phonology. Crediting this generator with the power to predict the results of its actions makes this model plausible, and provides the possibility of explanations in this area where none previously existed.

I now turn finally to the effect that the choice of a purely peripheralist control model, or a model in which centralist elements are admitted has on our view of language behaviour as a whole, embracing both production and perception. It should be noted that, in denying predictive power to the motor command generator, peripheralist accounts effectively disassociate the articulatory results from the central intention. Now, the logical relation between such an account of production and a MOTOR theory of speech perception may not be as strong as entailment, but the connection is certainly very strong and exclusive. In a model with centralist elements, on the other hand, where there is no disassociation between the centre and the periphery, it is possible to propose at least one alternative — namely that it may be perceptual criteria, embodied in some way in the phonological specification, that govern production, rather than the other way around. The immediate point is not whether this is

in fact a more attractive alternative, but that given centralist elements in the control of production, there is an alternative.

*Language Centre  
University of Essex, Colchester*

#### REFERENCE

- Haggard, M.P.  
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