How oscillatory is speech production?

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Some motor tasks are clearly cyclical or oscillatory in nature. Examples include swimming, walking, juggling, or turning a crank. A number of computational models have posited the use of oscillatory dynamical systems to generate such movements, and oscillatory neural circuits have been identified in non-human biological systems. Other tasks are clearly not oscillatory, including reaches to objects and baseball swings. Such tasks are far less amenable to control via oscillatory circuitry, and accordingly most models of these behaviors involve non-oscillatory control mechanisms.

Speech is a task that falls somewhere in between these two extremes. There is a rhythmic (though not strictly periodic) nature to the opening and closing movements of the jaw and other articulators as they move between vowels and consonants in normal conversational speech. However, superimposed on this rhythmic prosodic structure is a segmental structure consisting of highly differentiated articulator movements for individual phonemes. Since the ordering of phonemes changes constantly during natural speech, it is difficult to envision that oscillatory circuitry is optimal for controlling the segmental aspects of speech except possibly tasks that are purposely designed to be oscillatory, for example diadochokinesis tasks involving rapidly repeated production of a single syllable or multi-syllable string.

The question of which aspects of speech are controlled by oscillatory circuits has been directly or indirectly addressed by different theoretical frameworks, including the task-dynamic model and the DIVA model. These models have been mathematically formulated and therefore make specific, and sometimes quite different, predictions regarding the neural mechanisms underlying speech. To date, very little information regarding the temporal dynamics of neural activity in the speech motor system has been collected because invasive neural recordings are extremely rare in humans. However, recent years have seen the development of brain-computer interfaces that involve implantation of electrodes into the cerebral cortex of profoundly paralyzed individuals. Careful analysis of data collected from these electrodes should shed new light on speech motor control mechanisms and may provide a means for resolving the issues discussed in this session.