

CHAPTER 5

Conclusion

The three studies described in this dissertation each support the idea that speech motor areas are involved in speech perception. The first study (Wilson et al., 2004; chapter 2) demonstrated an overlap between speech perception and speech production in premotor cortex overlapping with primary motor cortex. Meaningless monosyllables were used as stimuli in order to rule out any lexical, syntactic or semantic processing. This was the first study to explicitly demonstrate an overlap between speech perception and speech production in the same individual subjects. The premotor area that was responsive to speech was surprisingly superior. It was clearly distinct from more inferior ventral premotor activations which have been observed for overt phonological processing (e.g. Zatorre et al., 1992, 1996).

In the second study (Wilson & Iacoboni, 2006; chapter 3), our aim was to test the hypothesis that the premotor area observed in the first study was involved in coding articulatory representations of perceived speech. Native English-speaking subjects were presented with consonants from a variety of languages other than English, which differed in the extent to which English speakers are able to articulate them. We reasoned that signal in regions involved in articulatory coding would correlate with the extent to which

it was possible to obtain an articulatory representation. The results proved to be more complex: speech-responsive premotor regions did distinguish between native and non-native phonemes in perception, but only auditory areas in the bilateral superior temporal cortex were correlated with the producibility of non-native phonemes. Moreover, correlations with producibility were negative: there was greater signal change for the phonemes which were more difficult to produce. We proposed that in speech perception, premotor regions are involved in generating candidate phonemic categorizations, whose predicted acoustic consequences are then compared to the auditory input in superior temporal cortex, with the correlated activity observed constituting a kind of error signal. Another interesting finding of this study was robust functional connectivity between premotor and posterior superior temporal speech-responsive regions during the task, further supporting a functional link between these areas.

The final study (Wilson et al., submitted; chapter 4) was concerned with higher levels of linguistic processing. Subjects were presented with auditory or audiovisual narratives. When narrative processing was compared to rest, relatively little activity was observed in frontal regions, which has also been the case in many previous studies of narrative comprehension. This is a challenge to the view that speech motor areas in the frontal lobe are involved in perceiving speech. We carried out an intersubject correlational analysis (Hasson et al., 2004) which identifies voxels which tend to have correlated timecourses across subjects, regardless of whether they show signal increase or decrease relative to rest. This analysis revealed that extensive bilateral inferior frontal and premotor regions were correlated across subjects. These areas must be sensitive to time-varying properties

of the linguistic input or the processing which it entails. Several frontal regions primarily in the left hemisphere were more strongly intercorrelated for auditory speech than audiovisual speech, which we argued may reflect increased importance of the speech motor processes under challenging perceptual conditions, since the narratives were difficult to understand over the background scanner noise, especially when there was no visual input. These regions were found in ventral premotor cortex and prefrontal areas, which would presumably reflect higher levels of linguistic processing than the premotor area observed in the prior two studies.

Taken together with findings from previous neuroimaging studies and other methodologies, our data suggest that there are two premotor regions which play a role in speech perception. One is the superior ventral premotor area located in Brodmann Area 6 observed in the first two studies, which we argued plays a role in directing attention to phonetic form, and may be a critical early component of an auditory-motor pathway. The second is a ventral premotor area centered around the dorsal part of Brodmann Area 44, which is most likely to code articulatory representations of perceived speech.

Probably the most central question to be addressed by future research is whether speech motor areas are only important for overt phonological and phonetic tasks (Hickok & Poeppel, 2000, 2004), or whether they play an essential role in normal speech perception, perhaps especially when the acoustic signal is degraded (Callan et al., 2004). In real-life contexts, perception of speech in noise is the norm, not the exception. Speech perception in background noise poses a problem in particular for sufferers of hearing loss, which affects approximately ten percent of the population in the United States. Hopefully

the data presented and issues discussed in this dissertation will contribute to a better understanding of the role of speech motor areas in speech perception.