An Adaptive Memory Model for Speech Re-training of Adults with Acquired Hearing Loss

This paper describes a neocortical column-based, hierarchical adaptive memory model of language acquisition and its application to the retraining of adults with acquired hearing loss. Speech error patterns and speech retraining methods for such adult subjects are examined in light of this model. The general model builds upon the neurocognition of neocortical on-center off-surround neural architectures (Mountcastle 1957, 1978) and the neural dynamics of speech perception and categorization (Grossberg 1972, Grossberg et al. 1997, Loritz 1999), and it is realized as a specific computational model, CLARNET (Koutsomitopoulou, 2004).

Speech of adults with acquired hearing loss is characterized by progressive degeneration as auditory feedback progressively deteriorates (Cowie & Douglas-Cowie 1992, Kerr & Cowie 1997). Speech retraining is possible via activation and reinforcement of acoustic memories usually with the help of quality hearing aids and other assistive listening devices. However, amplification, although necessary, is not a sufficient condition for impaired speech correction and retraining.

This study examines the role of memory in the ongoing speech retraining of HOH adults. The interaction between long-term learning and short-term memory activation is examined as 'new' (i.e. previously un-heard) auditory input is introduced.

The model elucidates how specific categorical predictions are made that affect speech perception (and subsequently speech production) of certain "ambiguous" phonological input in the hearing impaired brain.

It will be shown that much like in the case of ESL speakers, hearing impaired adults rely on rebound-based neocortical learning that can effect a type of phonological "code-switching". This may initially cause a proliferation of speech errors until and unless the newly mis-perceived sound patterns become successfully assimilated and properly re-categorized by underlying neural mechanisms.

CLARNET models of antagonistic dipole relationships between current phonological input and previously-acquired speech patterns illustrate several of these processes. Specifically, by selectively exciting and/or inhibiting reactive associations with previously-acquired speech patterns, such models emulate the speech retraining process and corroborate empirical studies in speech error analysis and aural rehabilitation for the HOH, that clearly point to the comparative difficulty of HOH subjects to learn out of context linguistic input simply by repetition and, conversely, the greater facilitation of the learning process via the introduction of dipole structures.

The ramifications of the above line of investigation affect our expectations in experimental tasks; for instance, it follows that poor performance of the HOH in auditory tasks is not simply or uniformly atrributable to poor short-term memory capabilities as may be presumed, but is instead more usefully attributed to certain auditory neural processes that have specific deficits under conditions of hearing impairment. It is predicted that these deficits can be effectively managed via cognitively appropriate retraining techniques. Unlike rote learning, which is resistant to correction and retraining, neocortical learning is effected via rebounds that allow for assimilation of new instances of phonological perception, or, in the case of systemic phonological exceptions, categorization of these instances in new classes. On this neurocognitive basis, certain scenaria are described of speech retraining for the mitigation of speech error patterns of adults with acquired hearing loss.

References

Cowie R., Douglas-Cowie, E. (1992): *Postlingually Acquired Deafness. Speech Deterioration and the Wider Consequences.* Berlin, New York: de Gruyter.

Grossberg, S. (1972): A neural theory of punishment and avoidance. i: qualitative theory. *Mathematical Biosciences*, 15, 39-67.

Grossberg, S., Boardman, I., Cohen, M. (1997): Neural dynamics of variable-rate speech categorization. *Journal of Experimental Psychology: Human Perception and Performance.* 23, 483-503.

Kerr P., Cowie, R. (1997): Acquired deafness: a multi-dimensional experience. *Brit Journ Audiol,* 31, 177-188.

Koutsomitopoulou, E. (2004): *A neural network model for the representation of natural language.* PhD thesis, Georgetown University, Washington DC. Ann Arbor: UMI. 65:6, 3137058.

Loritz, D. (1999): *How the Brain Evolved Language.* Oxford University Press.

Mountcastle, V. (1957): Modality and topographic properties of single neurons of cat's somatic sensory cortex. *Journal of Neurophysiology*, 20, 408-34.

Mountcastle, V. (1978): An organizing principle for cerebral function: The unit model and the distributed system. In: G. M. Edelman and V. B. Mountcastle (eds.). *The mindful Brain.* Cambridge, Mass: MIT Press.