# SPEECH PRODUCTION AND SPEECH PERCEPTION

Organized by Carol Fowler and Elliot Saltzman

## Using Sound to Solve Syntactic Problems: The Role of Phonology in Grammatical Category Assignments

Michael H. Kelly
Department of Psychology, University of Pennsylvania, Philadelphia, PA, U.S.A.

One traditional claim about language states that the phonological structure of words is generally uncorrelated with nonphonological domains (the arbitrariness assumption). This assumption in turn reflects a more general view that different domains of language structure are independent, both in processing and representation (the modularity assumption). As a result, phonology has been generally neglected as a source of information for solving certain problems that seem fundamentally nonphonological. In particular, successful learning and processing of language requires that words be classified into their appropriate grammatical categories, such as noun and verb. In general, semantic and syntactic information has been cited as the principal cues for grammatical category assignment. Evidence will be presented that the arbitrariness and modularity assumptions are false in the area of phonology and grammatical class correlations. In particular: (1) numerous correlations between phonology and grammatical class exist, (2) some of these correlations are large and can pervade the entire lexicon of a language, and hence involve thousands of words, (3) experiments have repeatedly found that adults and children have learned these correlations, and (4) some explanations for how these correlations arose can be proposed and evaluated. These phenomena indicate that the neglect of phonology as an information source for grammatical category assignment has no evidentiary basis at this point. Some further implications will be discussed in areas such as the organization of the mental lexicon and rates of lexical acquisition by children.

## The Nonlinear Dynamics of Categorical Perception

Betty Tuller
Department of Psychology and Center for Complex Systems,
Florida Atlantic University, Boca Raton, FL, U.S.A.

Although categorical perception is perhaps the most replicated phenomenon of speech perception research, a satisfying explanation of the phenomenon is still lacking. The recent literature on categorical perception has progressed beyond simply demonstrating that speech can be perceived categorically. Emperical extensions include determining the conditions under which non-speech stimuli can be perceived categorically, conditions that bias speech perception to be more continuous in nature, and determining what really constitutes phonetically significant acoustic change. In all of those studies, multiple tokens of each level of the manipulated acoustic parameter or parameters are randomized, then presented to listeners. This classical methodology is deficient for our purposes, because one cannot examine the dynamic nature of the perceptual states. In the present experiment, we used a methodological strategy entirely different from that typically used. Rather than randomly assigning treatment levels we gradually increase or decrease a single acoustic parameter in order to exploit possible nonlinearities and observe phase transitions. More generally, we are using the concept of stability as described in theories of self-organization and pattern formation in nonequilibrium systems, with the aim of understanding phonetic change as a pattern formation process.

Experimental stimuli consisted of two 'say-stay' continua, with two levels of F1 onset frequency and gap duration after the /s/ changing in 20 steps of 4 ms each. Although nine subjects participated in the experiment, all data conformed to one of four basic patterns: 1) no real difference in the phonetic boundary as a function of direction of gap change; 2) a classic hysteresis effect, a signature property of nonlinear dynamical systems; 3) an 'anticipation' effect, possibly akin to earlier work on selective adaptation and range effects in speech perception; 4) an evolution over trials, from hysteresis to 'anticipation'.

What type of dynamical system could account for these patterns of perceptual change? We first specified a potential function that corresponds to the layout of phonetic (attractor) states, and how that layout alters as the control parameter, here gap duration, is changed. The model reproduces the observed features of the experimental data, i.e., hysteresis, 'anticipation', a single boundary, and the progression from hysteresis to anticipation over multiple trials. The model also makes certain predictions about perception, currently being tested, that bear on the relative discriminability of the stimuli, as a function of direction of control parameter change.

## Exploring the Perceptual Nature of the McGurk Effect Using an AXB Discrimination Test

Lawrence D. Rosenblum and Helena M.Saldaña
University of California, Riverside, CA, U.S.A.

In the McGurk effect, visual information for articulation affects auditory judgments of speech syllables. Recently, questions have arisen concerning whether this effect is perceptual or post-perceptual in nature (Rosenblum, 1988). One way of exploring this issue is to determine the degree to which a visually-influenced syllable sounds like its auditory-alone counterpart. The hypothesis was made that if the McGurk effect is truly perceptual in nature, then observers should have difficulty discriminating the sound of a visually-influenced syllable from an audio-alone syllable. A series of experiments using natural and synthetic speech were conducted which implemented an AXB matching procedure to determine if a visually-influenced /va/ (audio /ba/ video /va/) and an audio-visual consistent /va/ (audio /va/; video /va/) sounded equally like an audio-alone /va/ as is predicted by the above hypothesis. Initial results suggested that observers are more likely to match the audio /va/ to the audio-visual consistent /va/ than to the visually-influenced /va/. However, the results of subsequent experiments suggest that this matching might be based simply on similarities in acoustic characteristics and not on differential phonetic categorizations of the stimuli. The results will be discussed in terms of motor theory, ecological, and FLMP approaches to speech perception.

# Language-Specific Effects on Perception of Discourse Prosody Categories by 2-4 Month Olds

Catherine C. Best
Haskins Laboratories, New Haven, CT, and
Psychology Department, Wesleyan University, Middletown, CT, U.S.A.

Language-specific effects appear in infants' discrimination of segmental phonetic contrasts by 10-12 months. Whereas younger infants discriminate both native and non-native contrasts, 10-12 month-olds fail to discriminate the majority of non-native contrasts tested. This may be analogous to the difficulty adults display in discriminating phonetic contrasts from unfamiliar languages. But numerous reports suggest that language-specific influences on infants' perception of prosodic properties in speech appear much earlier than 10-12 months. Nonetheless, it is difficult to compare the two sets of infant findings, because nearly all phonetic studies have examined linguistically-relevant contrasts, whereas none of the prosodic studies have done so. Therefore, we recently tested discrimination of the discourse prosody contrast between questions and statements in native and non-native speech to young infants. We found little evidence of language-specific effects in discrimination of these prosodic categories by 6-8 or 10-12 month olds (Best, Levitt, & McRoberts, 1991). The present report extended the investigation to 2-4 month olds, a range which includes both the age of the addressee of the stimulus utterances and the ages at which earlier studies had found language-specific prosodic influences. The task was a habituation test of category discrimination, employing conditioned visual fixation as the operant. The infants had to detect abstract invariants in the varying prosodic contours of diverse questions and/or statements in either the native language (English) or an unfamiliar language (Spanish), in order to recognize a within-language shift in the stimulus utterances following habituation. All infants received one test in Spanish and another in English, with order counterbalanced across infants. Half of the infants were tested for discrimination of a categorical change between questions and statements (or vice versa). The other half participated in a control condition, in which they were tested for discrimination of an arbitrary (non-categorical) within-language change from one mixed set of questions and statements to a different mixed set. The 2-4 month old subjects in the present study showed language-specific constraints in perception. Unlike the older infants in the previous study, they discriminated the categorical change only in their native language, and failed to discriminate the arbitrary change in either language. The results will be discussed in terms of possible developmental changes in the infant's attentional focus during perceptual learning about native infant-directed speech, whose prosodic and semantic properties change as the infant develops and approaches the actual use of language. (Supported by NIH grants HD-01994 and DC 00403).