Stem-, Spraak- en Taalpathologie
Vol. 14, 2006, Supplement, pp. i-ii
32.8310/Supplement/1406-i

PREFACE

This Supplement contains the abstracts of the fifth edition of the International Conference on Speech Motor Control, Nijmegen, The Netherlands, June 7 to 10, **2006**. Like the previous editions, this conference highlights new trends and state-of-the-art approaches in theoretical and applied research in the area of normal and disordered speech motor control.

Since the first edition in **1985**, the series of international Nijmegen conferences on speech motor control have reflected tremendous progress in this area. The initial focus was on applications in the just expanding field of motor control in stuttering. The second conference (**1990**) highlighted the development of more general motor control models and the inclusion of higher order psychomotor and psycholinguistic processes, broadening the scope to other motor speech disorders than stuttering. At the third conference (**1996**), more emphasis was put on the emerging field of brain imaging. In addition, development of speech motor control became a prominent topic. At the fourth conference (**2001**), we witnessed the introduction of important theoretical neurophysiological and neurobehavioral concepts, and a strong interest in the 'interface' between higher order cognitive/psycholinguistic processes and speech production.

In recent years, one of the major developments we have observed is a stronger interdisciplinary collaboration in the field of speech motor research. Integration seems to be the key-concept: integration of principles and models of perception-action relations in general and speech as an audio-visual-speech-motor performance in particular; biomechanical, and neurobiological aspects of motor control in general, and the biomechanics and neurological control mechanisms of speech in particular; the genetics of motor learning (automation) and of language disorders in general, and of speech motor learning and phonology in particular. Thus, new fundamental insights in speech motor control processes are emerging, showing a stronger embedding in general aspects of the origin, development and maintenance of cognitive, linguistic and motor processes as well as demonstrating its unique properties as part of the human genetic make-up.

Special topics of the 2006 conference are:
- theory and modeling of speech motor control and coordination
- neurological organization and neural functioning of speech
- genetic aspects of speech disorders
- interaction of functional neural systems for language and speech production
- functional brain imaging in speech and speech disorders
- developmental issues in speech motor control
- the speech motor control perspective in stuttering
- research in neurogenic speech disorders
- measurement of speech motor behaviors
- clinical phonetics in neurological conditions
- use of speech motor behaviors as outcome measures in clinical treatment
- future directions in speech motor research

Conference organization

In order to fulfil the main purpose of the conference a relatively large number of keynote speakers have been invited to present tutorials on specific topics. To stimulate a lively interaction, all presentations are plenary. Because of time constraints only a very limited number of submissions could be scheduled as oral presentations. This amounted to less than one quarter of those submissions that were rated as acceptable for admission. For this reason thematic poster sessions form a major part of the conference program, offering a large variety of research in speech motor control in normal and deviant speech from all over the world. Many conferences advocate the policy to value oral presentations and posters equally, as do the organizers of this conference. In order to underscore this policy a special prize will be awarded to the most informative and well-designed poster.

The Radboud University and the organizing departments are proud to attract such high-level researchers and clinical workers in the field to travel to Nijmegen and report on the results of their theoretical and empirical work to this platform of scientific exchange and discussion.

We look forward to a stimulating and productive conference,

Ben Maassen Nijmegen
Pascal van Lieshout Toronto

May 2006

Program committee

- Ben Maassen, chair (Radboud University Nijmegen Medical Centre)
- Pascal H.H.M. van Lieshout, co-chair (Dept. of Speech-Language Pathology, Oral Dynamics Lab, University of Toronto, Canada)
- Raymond D. Kent (Waisman Center, University of Wisconsin, USA)
- Wouter Hulstijn (NICI, Radboud University Nijmegen)
- Hermann Ackermann (Department of Neurology, University of Tübingen, Germany)
- Peter Hagoort (F.C. Donders Center for Cognitive Neuroimaging, Radboud University Nijmegen)

Abstracts editor

- Hayo Terband (Medical Psychology, ENT, Radboud University Nijmegen Medical Centre)

Website (with full conference program)

http://www.slp-nijmegen.nl/smc2006/

CORTICAL PLASTICITY IN SPEECH PRODUCTION IN THE ADULT BRAIN

Miranda van Turennout
F.C. Donders Centre for Cognitive Neuroimaging, Behavioral Science Institute, Radboud University Nijmegen, The Netherlands
Miranda.vanTurennout@fcdonders.ru.nl

Short Overview

Language performance is improved by experience. This is clearly noticeable during development, but even in adulthood language skills are highly dynamic. In spite of this apparent capacity for change, for a long time the neural organization of the mature language system was assumed to be fixed by the end of development. However, animal research has demonstrated cortical plasticity in the representation of sensory and motor maps in the adult brain. In addition, with the increase in functional brain-imaging techniques, evidence has been provided indicating experience-induced plasticity in the intact adult human brain. Recent brain-imaging data have clearly revealed that the neural circuitry underlying normal speech production is modified by experience. Even relatively simple experiences, such as naming an object once, involve rapidly induced, very long lasting modifications of cortical representations (van Turennout et al., 2000, 2003). Changes occur in early sensory as well as in higher-order brain regions, suggesting that experience modifies neural representations at different levels of the language system. In this presentation cortical plasticity in the speech production system will be further explored. The focus will be on recent fMRI studies revealing training-related formation of syllable-specific, phonological units in adult cortex.

During a series of training sessions, subjects repeatedly named pseudowords, each of which consisted of two pseudosyllables (i.e., pronounceable strings of phonemes that do not exist as a syllabic unit). The imaging data showed that this extensive training led a shift in cortical activity from areas involved in the online generation of a phonological sequence to a more automatic retrieval of a newly stored syllable-specific code. The results suggest that the role of premotor cortex in speech production is highly dynamic, and can be altered by experience.

References

Van Turennout, M., Ellmore, T., & Martin, A. (2000). Long-lasting cortical plasticity in the object naming system. *Nature Neuroscience*, *3,* 1329-1334.

Van Turennout, M., Bielamowicz, L., & Martin, A. (2003). Modulation of neural activity during object naming: Effects of time and practice. *Cerebral Cortex*, *13*, 381-391.

FOXP2 AND THE NEUROANATOMY OF SPEECH AND LANGUAGE

Faraneh Vargha-Khadem
UCL Institute of Child Health, University College London, and Great Ormond Street Hospital for Children, London, United Kingdom.
fkhadem@ich.ucl.ac.uk

Short Overview

The 'core' deficit in the affected KE family members is an orofacial and verbal dyspraxia. This suggests an underlying impairment in the rapid selection and accurate sequencing of orofacial movements that are most evident in speech. Structural neuro-imaging in the affected members revealed bilateral abnormalities in a number of motor, and speech and language-related brain regions. Functional neuroimaging during verb generation and repetition tasks disclosed a distinctly atypical pattern of activation, viz. diffuse, bilateral, and located predominantly in posterior cortical regions. Direct compari-son between affected and unaffected family members indicated that the FOXP2 mutation is associated with significant underactivation in several regions that had been found to be morphologically abnormal, including Broca's area as well as the inferior frontal gyrus and putamen on the right. Together, these structural and functional MR results provide a coherent explanation for the affected members' striking and persistent disorder.

The neuropsychological and neuroimaging findings will be related to the genetic basis of the disorder in the KE family, and to the pattern of gene expression during embryological development in the human embryo and in mice. The convergence of data from the behavioural, neuroimaging, and gene expression studies lead to a tentative model of the neuroanatomy of the speech and language system.

A number of neuropsychological studies will be described to identify the core phenotype of the disorder. Structural imaging studies, using voxel-based morphometry, indicate more or less grey matter in the key brain regions involved in motor programming. Finally, fMRI paradigms administered during word retrieval and word repetition tasks provide evidence of abnormal distribution of activation, as well as areas of underactivation during the performance of these speech and language tasks.

The discovery of the FOXP2 gene and the identification of the phenotype of verbal and orofacial dyspraxia have provided an opportunity to understand the brain mechanisms involved in the uniquely human attribute of articulate and intelligible speech. From a clinical standpoint, it is now possible to identify children who are at risk of developing speech and language problems resulting from deletions/mutations of the FOXP2 gene with a view to early intervention.

References

Vargha-Khadem, F., Gadian, D.G., Copp, A., & Mishkin, M. (2005). FOXP2 and the neuroanatomy of speech and language. *Nature Reviews Neuroscience*, *6*, 131-138.

Liegeois, F., et al. (2003). Functional MRI abnormalities during covert speech associated with FOXP2 gene mutation. *Nature Neuroscience*, *6(11)*, 1230-1237.

Watkins, K.E., Dronkers, N., & Vargha-Khadem, F. (2002). Behavioural analysis of an inherited speech and language disorder: comparison with acquired aphasia. *Brain*, *125*, 452-464.

CEREBRAL NETWORKS OF SPEECH MOTOR CONTROL: FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI) DATA

Hermann Ackermann, Klaus Mathiak, Ingo Hertrich, Wolfgang Grodd, Axel Riecker
Hertie Institute for Clinical Brain Research, University of Tübingen, Germany
hermann.ackermann@uni-tuebingen.de

Introduction

So far, our knowledge of the cerebral correlates of speech motor control is predominantly based on clinical studies. Functional brain imaging such as positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) now provide a further approach in this regard.

Oral diadochokinesis is considered as being one of the most sensitive clinical tests of speech motor deficits. A reduced maximum syllable repetition rate has been observed in patients with spastic or ataxic dysarthria. In contrast to these findings, subgroups of patients with Wilson`s or Parkinson`s disease even may exhibit "speech hastening", i.e., involuntary acceleration of speech tempo. In order to further elucidate the cerebral mechanisms of speech rate control, fMRI was conducted during syllable repetitions.

Methods

Eight subjects performed two different tasks in a 1.5 T MRI scanner: (i) passive listening to click trains via earphones (2.0, 2.5, 3.0, 4.0, 5.0, and 6.0 Hz), (ii) syllabe repetitions, externally or internally paced, at these rates.

Results and Discussion

A subtraction approach (repetitions vs. listening) revealed bilateral hemodynamic responses within the mesiofrontal and sensorimotor cortex, the basal ganglia and the cerebellum (two cerebellar activation spots on both sides). In contrast, dorsolateral-frontal premotor cortex and anterior insula showed left-sided activation only. Beyond these topographic information, a parametric approach to signal analysis and functional connectivity analyses provided further insights into the brain mechanisms of speech motor control. (a) Calculation of rate / response functions yielded positive-linear relationships between repetition frequency and hemodynamic activation within cortical structures, a negative rate / response function of the basal ganglia, and a step-like increase of the fMRI signal at about 3 Hz within both cerebellar hemispheres. (b) Analysis of the temporal dynamics of hemodynamic activation showed the cortical and subcortical brain regions participating in speech motor control to be organized into two separate networks, presumably, bound to movement preparation and movement execution, respectively.

References

Ackermann, H., Riecker, A., & Wildgruber, D. (2004). Functional brain imaging of motor aspects of speech production. In: B. Maassen, R.D. Kent, H.F.M. Peters, P.H.M.M. van Lieshout, & W. Hulstijn (Eds.) *Speech Motor Control in Normal and Disordered Speech*, 85-111. Oxford: Oxford University Press.

Riecker, A., Mathiak, K., Wildgruber, D., Erb, M., Hertrich, I., Grodd, W., & Ackermann, H. (2005). fMRI reveals two distinct cerebral networks subserving speech motor control. *Neurology*, *64*, 700–706.

DISSOCIATION OF MUSICAL PITCH AND RHYTHM PRODUCTION FROM DYSPROSODIC SPEECH IN FOCAL BRAIN DAMAGE

Diana Van Lancker Sidtis[1,2], Gina Canterucci[1]
[1]*New York University,* [2]*Nathan Kline Institute for Psychiatric Disorders, NY USA*
drv1@nyu.edu

Introduction

The role of pitch and rhythm ability in dysprosodic speech and the relationship of musical pitch and rhythm to the melody of speech are related in complex ways (Basso, 1998). This study benefited from the opportunity to examine in detail two musically trained, severely dysprosodic patients who had sustained cortical and subcortical damage from stroke.

Methods and Results

Patient 1 is a 50-year-old right-handed male who sustained a frontotemporoparietal right-sided infarct. His speech was dysprosodic in conversation and repetition. He was a singer, but after the stroke could no longer sing. Accuracies of pitch and rhythm of familiar songs were analyzed and compared to normal control subjects matched in age and musical experience. Patient 2 is 36-year-old, right-handed female who suffered basal ganglia infarcts. She was dysprosodic in conversation but improved in imitation (Van Lancker Sidtis et al., in press). She sang prior to her injury. Singing was assessed with pitch and rhythm accuracy measures taken. For previously familiar songs (e.g., Tom Dooley), compared to the normal group, Patient 1 produced few correct pitches (17% vs 99%), but rhythmic component was intact: Patient 2 sang (e.g., Amazing Grace) with accurate pitch and rhythm.

Discussion

These two patients with dysprosodic speech following single strokes showed marked differences in related parameters of pitch and rhythm in musical production, with retention of rhythm despite musical pitch failure in Patient 1, and retention of both musical pitch and rhythm function in Patient 2. In agreement with previous studies, these cases reveal a dissociation in performance between musical pitch and rhythm, and between dysprosody of speech and musical pitch control (Alcock et al., 2000; Bogen &Gordon, 1971).

References

Alcock, K., Wade, D., Anslow, P., & Passhingham, R.E. (2000). Pitch and timing abilities in adult left-hemisphere-dysphasic and right hemisphere damaged subjects. *Brain and Language*, *75*, 47-64.

Basso, A. (1998). The neuropsychology of music. In G. Denes (Ed.) *Handbook of clinical and experimental neuropsychology*. Amsterdam: Elsevier, 409-418.

Bogen, J.E. & Gordon, H. (1971). Musical tests for functional lateralization with intracarotid amobarbital. *Nature*, *230*, 524-525.

Van Lancker Sidtis, D., Pachana, N., Cummings, J., & Sidtis, J. (in press) Dysprosodic speech following basal ganglia insult: Toward a conceptual framework for the study of the cerebral representation of prosody. *Brain and Language*.

FMRI ACTIVATION DURING ORAL-MOTOR SEQUENCES VERSUS DIADOCHOKINESIS

Angela Morgan[1,2], Faraneh Vargha-Khadem[1], Alan Connelly[3], Frédérique Liégeois[1,2]
[1]Developmental Cognitive Neuroscience Unit, Institute of Child Health, University College London, [2]Harrison Research Centre, The Children's Trust, Tadworth, [3]Radiology & Physics, Institute of Child Health, University College London, United Kingdom
angela.morgan@ich.ucl.ac.uk

Introduction

The neural substrate for motor speech production has not been well defined, aside from that a crucial role for the posterior part of Broca's area (pars opercularis of the inferior frontal gyrus) has been well established through electrical stimulation[1-2] and lesion[3] studies. Furthermore, whether non-speech motor production (oral-motor function) shares the same neural substrate as speech motor function (diadochokinesis, ddk) has not, to our knowledge, been systematically investigated. Despite this lack of evidence, both oral-motor and ddk tasks are commonly used by speech and language clinicians and researchers in the behavioural evaluation and management of motor speech impairment. The objective of the present study was to determine (i)which brain regions are activated in common between the production of oral-motor and ddk sequences, and (ii)which brain regions are uniquely activated during oral-motor and ddk sequences.

Methods and Results

The present study examined brain activation during the execution of diadochokinetic syllable sequences and oral-motor sequences vs. rest in 10 healthy control subjects using a block design functional MRI paradigm. SPM was used for statistical analyses of the following contrasts: oral-motor vs. rest; ddk vs. rest; (oral-motor vs. rest) vs. (ddk vs. rest); and a conjunction analysis (oral-motor vs. rest) – (ddk vs.rest). The production of oral-motor and ddk sequences activated bilaterally a common network including the pre and post-central gyrus, the putamen and the cerebellum. As hypothesized, the left pars opercularis or Brodmann's area 44 (BA 44) was uniquely activated during the ddk task.

Discussion

These findings indicate that oral-motor and ddk tasks share an extensive neural substrate, involving sensorimotor and subcortical regions. Interestingly, BA 44 was uniquely activated during the ddk task. This preliminary finding has significant implications for the use of non-speech oral-motor tasks for both assessment and treatment of motor speech impairment, raising the question of whether performance on oral-motor tasks can be generalised to performance during speech motor production.

References

Ojemann, G.A., Ojemann, J.G., Lettich, E., & Berger, M.S. (1989). Cortical language localization in left, dominant hemisphere. An electrical stimulation mapping investigation in 117 patients. *Journal of Neurosurgery*, *71*, 316-326.

Duffau, H., et al. (2003). The role of dominant premotor cortex in language: A study using intraoperative functional mapping in awake patients. *Neuroimage*, *20*, 1903-1914.

Hillis, A. E., Work, M., Barker, P. B., Jacobs, M. A., Breese, E. L., & Maurer, K. (2004). Re-examining the brain regions crucial for orchestrating speech articulation. *Brain*, *127*, 1479-1487.

MODELING SPEECH PRODUCTION IN NORMAL AND ATAXIC SPEAKERS USING PERFORMANCE-BASED FUNCTIONAL IMAGING

John J. Sidtis
Nathan Kline Institute and New York University Medical School, New York, USA
john.sidtis@nyu.edu

Introduction

Functional imaging during speech production yields some results that are consistent with the findings of lesion studies, but many that are not. One problem is bilateral activation during behaviors that are clearly well lateralized in lesion studies. While neither the use of resting states or task subtractions solve this problem, the use of a performance-based analysis (PBA) incorporating data obtained during scanning yields imaging results closer to the lesion experience. The aim of these studies is to continue the development of a performance-based approach to functional imaging data that is consistent with the results of lesion studies.

Methods and Results

Blood flow was measured using Positron Emission Tomography (PET). Subjects repeated the syllables /pa, ta, ka/ as quickly as possible. Speech rate was predicted from blood flow data in 13 normal speakers. As rate increased, flow increased in Broca's area and decreased in the right caudate nucleus. This relationship was replicated in a group of 24 speakers with hereditary ataxia in whom the right cerebellum and the left superior temporal gyrus was involved. To investigate genotypic differences, data from 14 spinocerebellar ataxia type 1 (SCA1) and 5 spinocerebellar ataxia type 6 (SCA6) subjects were analyzed with respect to voice onset time (VOT). The mean VOT function was predicted by activity in the right cerebellum and left thalamus while the VOT variability function was predicted by activity in the right cerebellum and right superior temporal gyrus.

Discussion

There are serious discrepancies between the results of lesion studies and the results of functional imaging studies using analyses based on image contrasts. When image data are analyzed with respect to performance without resorting to the use of contrasts, the results are consistent with lesion data. Further, the inclusion of ataxic subjects provides a more elaborate model of motor control than that observed with normal speakers alone. A functional description of complex systems like that responsible for speech motor control may require performance-based analyses and studies of both normal and abnormal behavior.

References

Sidtis, J.J. (2000). From chronograph to functional image: What's next? *Brain and Cognition*, *42*, 75-77.

Sidtis, J.J., Strother, S.C., & Rottenberg, D.A. (2003). Predicting performance from functional imaging data: Methods matter. *NeuroImage*, *20*, 615-624.

Sidtis, J.J., Gomez, C., Naoum, A., Strother, S.C., & Rottenberg, D.A. (in press). Mapping cerebral blood flow during speech production in hereditary ataxia. *NeuroImage*.

BRAIN IMAGING IN CHILDREN

Christy L. Ludlow, Soo-Eun Chang
Laryngeal and Speech Section, National Institute of Neurological Disorders and Stroke, Bethesda, MD, USA
Ludlowc@ninds.nih.gov

Short overview

Previously, anatomical studies in adults who stutter found increases in right and left temporal planum volumes (Foundas et al., 2001) and reduced left to right temporal planum asymmetry (Foundas et al., 2004). Using voxel based morphometry, increased white matter volumes were found in the right superior temporal gyrus (Jäncke et al., 2004) while diffusion tensor imaging found reductions in white matter tracts in the subcentral sulcus beneath the laryngeal and tongue left sensorimotor cortices and in the inferior arcuate fascicle linking the temporal and frontal language areas (Sommers et al., 2002). Physiological studies using positron emission tomography found increases in right hemisphere motor areas, decreased auditory activation and increased left cerebellar activity in adults during stuttering (Fox et al., 2000); some of which may be compensatory (Braun et al., 1997).

Recent research has shown both functional and structural neuroplasticity, both in adults as a result of training and during development in children. During development, grey matter density (GMD) and thickness reduce more in the right than in the left temporal lobe leading to greater GMD in the left hemisphere (Toga et al., 2006) while increased white matter fiber density develops in the left over the right hemisphere in the arcuate fasiculus (Nucifora et al., 2005). Neuroplastic changes in the grey matter volume (GMV) can be induced with training in adults (Draganski et al., 2004) and following a lifetime of musical training both grey matter (Gaser and Schlaug, 2003) and white matter differences (Bengtsson et al., 2005) occur in the brain. Differences in brain anatomy and function previously seen in adults who stutter may reflect both differences in brain development and neuroplastic changes as a result of a lifetime of struggling with stuttering. Hence, imaging studies are needed in children who stutter.

We present preliminary findings measuring GMV in children 9-12 years comparing both persistent and recovered groups with their normally fluent peers. Reduced GMV occurred in the inferior frontal gyrus and anterior cingulate on the left, and the temporoparietal regions bilaterally. The recovered group also had less GMV in cerebellar regions compared to the other two groups. These results differ from previous findings of increased volume and white matter on the right in adults who stuttered. In childhood, regardless of recovery from stuttering, GMV was reduced in temporal speech areas in contrast with previous findings in adults who had volumetric increases in these regions. The reduced grey matter in brain substrates supporting speech in children who stuttered suggest that a lack of maturation/plasticity in these brain regions on the left may relate to difficulty achieving fluent speech. Some of the findings in adults who stutter may be due to compensatory neuroplasticity following a lifetime of stuttering.

References

Toga et al. (2006). Mapping brain maturation. *Trends in Neurosciences*, *29(3)*, 148-159.
Nucifora, G., et al. (2005). Leftward asymmetry in relative fiber density of the arcuate fasciculus. *NeuroReport*, *16(8)*, 791-794.
Draganski, B., et al. (2004). Changes in grey matter induced by training. *Nature*, *427*, 311-312.
Bengtsson, S.L., et al. (2005). Extensive piano practicing has regionally specific effects on white matter development. *Nature Neuroscience*, *8(9)*, 1148-1150.

NEURAL CONTROL OF VOLITIONAL HUMAN VOCALIZATION: AN EVENT-RELATED FMRI STUDY

Torrey M.J. Loucks, Kristina Simonyan, Christopher J. Poletto, Christy L. Ludlow
Laryngeal & Speech Section, National Institutes of Neurological Disorders & Stroke, Bethesda, MD, USA
louckst@ninds.nih.gov

Introduction

Vocalization is a complex sensorimotor behavior used for speech and non-linguistic expression. Phonation for speech (syllable production) is a learned behavior that is apparently controlled by a direct pathway from the inferolateral motor cortex to the nucleus ambiguus (Kuypers, 1958). Whispering for speech may not differ from phonation because both tasks involve volitional laryngeal control (Solomon et al., 1989). We predicted that either phonating or whispering syllables would involve the left inferolateral motor cortex in adult humans. On the other hand, emotional vocalizations, such as whimper, appear to be controlled by an indirect pathway originating in the anterior cingulate cortex (ACC) (Jurgens, 2002). Finally, an airway protection task, such as volitional throat-clear, may involve laryngeal and respiratory motor control, but not the speech or emotional expression systems.

Methods and Results

Event-related fMRI with sparse sampling was used to compare brain activation during phonation, syllabic whisper, non-linguistic whimper, and throat-clear in 12 adults (35 slices; 3.75*3.75*4.00 mm; TR-2 sec; Delay – 8.5 sec.). During each trial, the subject heard a model and repeated it. Following image pre-processing, the regression coefficients for each task were compared with repeated-measures ANOVA ($p<0.05$ corrected).

Phonation and whisper showed similar bilateral activation in the inferolateral motor cortex, insula and supplementary motor area (SMA) along with the left putamen and right superior temporal gyrus (STG). The contrast between phonation and whisper indicated minimal differences between these tasks. Whimper activation was similar to phonation, except the motor cortex response was left-lateralized and higher activation was observed in the ACC. Throat-clear differed from the vocalization tasks because the only responses were in the left insula and left IFG.

Discussion

Although ACC activation was greater during whimper, similar activation patterns occurred during phonation, whisper and whimper. This suggests a common neural system for vocalization including the motor cortex, insula, SMA, right STG, and putamen with less dissociation between speech and emotional expression than expected from animal studies[3]. Because throat-clear, did not activate the same brain regions, it appears that vocalization involves a more elaborated system than laryngeal and respiratory motor control alone.

References

Jurgens, U. (2002). Neural pathways underlying vocal control. *Neuroscience & Biobehavioral Reviews*, *26(2)*, 235-258.

Kuypers, H.G.J.M. (1958). Cortico-bulbar connexions to the pons and lower brainstem in man. An anatomical study. *Brain*, *81*, 364-388.

Solomon, N.P., McCall, G.N., Trosset, M.W., & Gray, W.C. (1989). Laryngeal configuration and constriction during two types of whispering. Journal of Speech & Hearing Research, *32(1)*, 161-174.

PHONATORY STABILITY AND MOBILITY AS PHENOTYPES

Eugene H. Buder[1], Kim Corbin-Lewis[2], Hilary Coon[3], Lorraine O. Ramig[4]
[1]The University of Memphis, [2]Utah State University, [3]University of Utah,
[4]University of Colorado at Boulder, USA
ehbuder@memphis.edu

Introduction

Phonatory control requires both stability and mobility, as can be assessed in vowel prolongation and laryngeal diadochokinesis tasks respectively. Neuro-muscular mechanisms and normal variability for such control may be broadly understood, but the present investigation attempts to account for phenotypic factors in this variability. The research inquires whether there are family differences and heritability effects among stability and heritability measures, and whether such differences co-occur across families. Secondarily, the research also assesses covarying factors such as age, gender, the impact of visual feedback during recordings, and the effects of self-selected f_0 and SPL levels on phonatory stability.

Methods and Results

Data represent phonations (vowel prolongations and diadochokinetic productions of /a/ and /ha/) by adult members of 39 large 2 or 3 generation families recruited via the Utah Genetics Reference Project, for a total N of nearly 400. Vowel prolongations were analyzed by the modulogram technique, distinguishing several different types of phonatory modulations in both fundamental frequency (f_0) and sound pressure level (SPL) parameters, differing by frequency of modulation (e.g., wows vs. tremors vs. flutters), to represent classes and degrees of phonatory stability. Diadochokinesis recordings were analyzed for rate and accuracy using the KayPentax Motor Speech Profile program with spectrographic inspection, to represent degrees and accuracies of phonatory mobility. ANCOVA familiality analyses and SOLAR heritability estimation techniques (examining shared variance based on expectations of family members' differing degrees of shared genetic materials, also with covariates) revealed many significant phenotypic effects for both stability and mobility measures.

Discussion

Addressing our primary questions, the results indicate that there are family differences and heritability effects in degrees of mobility and in many, but not all, types of phonatory stability. The effects were focal (e.g., low-frequency tremors of SPL were highly familial and heritable, while overall variabilities in amplitude and higher-frequency flutters of f_0 were not). The stability and mobility effects did not generally correspond within families (e.g., families that were distinct in exhibiting modulated vowel prolongations were not the same families that distinguished themselves as either faster or slower in laryngeal mobility). Genomes for these participants have also been mapped. If a gene contributes to the observed variations, genetic linkage will be able to determine the approximate location of this gene. We will report preliminary evidence of these linkage analyses using DNA markers covering the genome at a 10-15 centiMorgan density in these families.

References

Almasy, L. & Blangero, J. (1998). Multipoint quantitative-trait linkage analysis in general pedigrees. *American Journal of Human Genetics, 62*, 1198-1211.

Buder, E.H. & Strand, E.A. (2003). Quantitative and graphic acoustic analysis of phonatory modulations: The modulogram. *Journal of Speech, Language, and Hearing Research, 46*, 475-490.

A COUPLED OSCILLATOR MODEL OF SPEECH PRODUCTION PLANNING

Louis Goldstein[1,2], Hosung Nam[1,2], Elliot Saltzman[1,3]
[1]*Haskins Laboratories,* [2]*Yale University, New Haven CT,* [3]*Boston University, MA, USA*
louis.goldstein@yale.edu

Overview

In an articulatory phonology framework, the phonetic information specific to linguistic units is embodied in the choice of articulatory gestures and their temporal patterning. We will describe a recently developed coupled oscillator model of how intergestural timing is planned, and will show how the model's representations account simultaneously for both the relative timing of gestures and the variability of those timing relations. The model makes explicit the traditional notion of syllable structure and explains cross-linguistic syllable type preferences.

In the model, each gesture of a syllable is associated with a nonlinear oscillator of a particular frequency. These gestural planning oscillators are coupled to one another in a pairwise fashion, where the coupling between a given pair is derived from a potential function that causes their relative phase to be attracted to a particular target value. Thus, the set of gestures and their coupling specifications define a *coupling graph* for the gestural oscillators in the planning model. The specifications are typically chosen from the set of intrinsically stable modes for oscillator pairs: in-phase and anti-phase. Syllable onsets are defined by in-phase coupling: *all* consonant gestures in the onset of a syllable are all coupled in-phase to the vowel. The first coda consonant is coupled anti-phase to the vowel. If there is more than one consonant gesture in an onset or coda, they are coupled anti-phase to one another as well.

During simulations of intergestural planning, the relative phases among the gestures are set to random initial values, and the task-dynamic model of intergestural phasing is used to modulate the relative phases over time until the oscillatory ensemble settles to a steady-state pattern. Once this steady-state pattern is reached, each oscillator's zero-phase is used to trigger the initiation of its associated gesture. When noise is added to the oscillators during simulations, the results reproduce the empirical differences between onsets and codas in both intergestural timing and its variability. Data showing differences in timing and variability in C-C sequences across three languages will be presented. By hypothesizing different coupling graphs for the languages, the differences in both timing and variability can be accounted for.

Finally, recent investigations of articulatory kinematics during speech errors will be reported that provide convergent empirical evidence for the role of coupled oscillators in speech production planning. These studies show that errors are dominated by intrusions of additional gestures without deletions of the intended ones. For example, when repeating the sequence "cop top," intrusions of tongue dorsum raising during /t/ and tongue tip raising during /k/ are found, even when the non-errorful gestures are fully produced. These errors can be understood within a coupled oscillator framework as resulting from bifurcations in the frequency-locking ratios of entrainment between the lip gesture and the tongue tip or dorsum gestures, from a 2:1 frequency ratio to a dynamically simpler and more stable 1:1 ratio.

References

Goldstein, L., Byrd, D.,& Saltzman, E. (in press). The role of vocal tract gestural action units in understanding the evolution of phonology. In: M. Arbib (Ed.) *From Action to Language: The Mirror Neuron System*.

Nam, H. & Saltzman, E., (2003). A competitive, coupled oscillator of syllable structure. *Proceedings of the XIIth International Congress of Phonetic Sciences*, Barcelona.

Saltzman, E. & Byrd, D., (2000). Task-dynamics of gestural timing: Phase windows and multifrequency rhythms. *Human Movement Science 19(4)*, 499-526.

COGNITIVE MOTOR CONSTRAINTS AND SPEECH: A PROSODIC THEORY

Frank Boutsen
University of Oklahoma Health Sciences Center: College of Allied Health, USA
frank-boutsen@ouhsc.edu

Short Overview

A model of prosody that lays out cognitive-motor domains in speech is presented. Consideration of its major tenets, i.e., that cognitive motor processes in speech are complex, context sensi tive and developmentally grounded in perception may bring forward a paradigm shift, not only in models of normal speech production but also in how neurogenic speech disorders are conceived, classified and assessed. As for the latter, it is proposed that in their framing speech processes rather speech components or neuropathology of movement become the organizing principle.

Kussmaul (1871) pioneered the traditional clinical neurological perspective on neurogenic speech disorders when he delimited the concept of dysarthria, confining it to the CNS pathology apart from language and functional/organic speech disorders. This broad neurologic roadmap, was refined in the 1940-ties by theories that began to assert a coupling between the still fairly amorphous dysarthria symptom complex and etiologies that were bound within specified levels /components of the central nervous system. It was, however, not until Peacher (1950) and Grewel (1957) wrote their seminal papers that speech-processes were seen as needing theoretical cover in what otherwise were still mainly neurological classifications of neurogenic speech disorders. Specifically, apart from also considering the hitherto neglected processes of respiration, phonation and resonation in their classification, Grewel accorded processes of attention and memory a penetrating role in speech while Peacher assigned those pertaining to rhythm and audition an essential role. Interestingly, Peacher also pointed out the need for resurveying the neurogenic speech disorders claiming that assessment of them was marred by subjectivity. Darley, Aronson and Brown's (1969a,b) study of the audible characteristics of the disordered speech of patients with a variety of neuropathologies was a credible attempt to fill the void. However, rather than following the route of experimental phonetics, they studied the speech patterns phenomenologically along perceptual dimensions. The results of their research confirmed that audible speech patterns characterize the dysarthrias distinctly and that these patterns can reliably be identified using the perceptual method. With minor extensions and modifications, the current Mayo classification adheres to the dysarthria types, thus defined, and distinguishes them as categorically different form apraxia of speech and other neurogenic speech disorders (e.g. stuttering, aprosodia). While this model still is the gold standard, the question remains as to whether the logical alternative of what was pursued, i.e., a survey based on relevant, speech (specific) processes might produce different answers pertaining to classification, assessment and treatment. The prosodic model presented here presents a virtual experiment in this regard. It picks up, in a way, where Peacher and Grewell left off. While drawing from advances in mirror neuron and field dynamics theory, an attempt is made to integrate recent data (e.g. Perkell) and models (Lindblom) from experimental phonetics, when outlining normal cognitive-motor speech processes, their gross neurophysiological underpinnings, as well as the overall goal domains they serve.

References

Lindblom, B. (1990). Explaining phonetic variation. In: W.J. Hardcastle & A. Marchal (Eds). *Speech production and speech modeling*, 403-439. New York: Kluwer.
Perkell, J.S., Guenther, F.G., et al. (2000). *Journal of Phonetics*, *28*, 233-272.

THE SOMATOSENSORY PRECISION REQUIREMENTS OF SPEECH PRODUCTION

David J. Ostry[1,2], Sazzad Nasir[1]
[1]*McGill University, Montreal, Canada,* [2]*Haskins Laboratories, New Haven, USA*
ostry@motion.psych.mcgill.ca

Introduction

Interest to date in precision in speech production has focused on kinematic adjustments related to auditory information. Here we provide evidence that somatosensory precision in speech is also important to the nervous system and is achieved through impedance or stiffness control.

Methods and Results

We used a robotic device to apply lateral loads to the jaw that altered the motion path and hence somatosensory feedback without affecting either vowel or consonant-related acoustics. The loads had greatest effect when the jaw was either at maximum elevation or at maximum opening, that is, during the consonant or vowel-related portion of an utterance. We found that with training subjects corrected for both vowel and consonant-related loads, such that the motion path and presumably the associated somatosensory input returned to that normally experienced under no-load conditions. Thus even in the absence of any effect on speech acoustics, somatosensory precision seems equally important for vowel-related movements and for consonants.

Discussion

The adaptation we observed differed in one important way from what we have observed previously (Tremblay et al., 2003) and from what is typically observed during studies of limb movement. Specifically, when loads were unexpectedly removed following training, we in no case observed a load-dependent after-effect. The absence of an after-effect is characteristic of adaptation based on impedance control. We tested this idea in several ways. First, we computed estimates of jaw impedance during learning. We found that impedance increased with adaptation, an observation that is consistent with the idea that impedance control is used to regulate variability. We carried out a direct test of the idea that subjects use impedance control by running a control study in which subjects first trained with loads comparable to those described above and then following adaptation we unexpectedly reversed the direction of load, that is, we switched it by 180°. We reasoned that if subjects achieved adaptation by impedance control then reversing the load should result in deflections that are comparable in magnitude to those observed at the end of adaptation (since impedance control produces resistance in all directions). This was indeed what we saw. The result is consistent with the idea that impedance control is used to achieve the adaptation observed here and more generally the precision requirements of orofacial movement.

References

Tremblay S., Shiller D.M., & Ostry D.J. (2003). Somatosensory basis of speech production. *Nature*, *423*, 866-869.

VARIABILITY OF NORTH AMERICAN ENGLISH /r/ PRODUCTION IN RESPONSE TO PALATAL PERTURBATION

Mark Tiede[1,2], Suzanne Boyce[3], Carol Espy-Wilson[4]
[1]Haskins Laboratories, New Haven, [2]Research Laboratory of Electronics, MIT, Cambridge, [3]University of Cincinnati, Cincinnati, [4]University of Maryland, College Park, USA
tiede@haskins.yale.edu

Introduction

It is well established that the lowered third formant that constitutes the primary acoustic percept of American English /r/ can be achieved with different tongue shapes in production (Delattre & Freeman, 1968). Broadly speaking these may be grouped into 'bunched' shapes (employing a tongue dorsum constriction) and 'retroflex' varieties (with a backward curled tip). There is also evidence showing that some speakers select between both of these production strategies depending on the coproduction context (Guenther et al., 1999), thus suggesting that the two production approaches are motorically equivalent. The research question pursued in this work is whether such motor equivalence in /r/ production is a generally accessible property of fluency in American English. In this study we probe this possibility through the use of an artificial palate. Specifically we ask (1) can speakers achieve acoustic equivalence when hampered by a palatal perturbation, (2) does use of the palate cause speakers to alternate between production variants, and (3) do speakers show the trading relations among speech articulators characteristic of motor equivalence.

Methods and Results

Subjects were fitted with a custom palatal prosthesis incorporating a tapered .5 cm protrusion along the alveolar ridge.Tongue, lip, and jaw position during production of /r/ in various contexts was observed using electromagnetometry with concurrently recorded audio under five conditions: before prosthesis placement; while wearing the prosthesis immediately following placement (initially with and then without masking noise); still wearing the prosthesis following an adaptation period; and immediately after prosthesis removal.Results show that some subjects (a majority) responded to the artificial palate by alternating between tongue shapes for /r/ production, while other subjects retained the same tongue shape across conditions.

Discussion

Regardless of tongue shape, no subjects showed significant differences across condition in formant patterns for /r/. All subjects showed a pattern of motor equivalence between tongue constriction location and corresponding lip protrusion, as displaced by the palate or as an aftereffect of wearing it.These results are consistent with the primacy of acoustic goals in the production of /r/.

References

Delattre, P. & Freeman, D. (1968). A dialect study of American R's by X-ray motion picture. *Linguistics*, *44*, 29-68.

Guenther, F., Espy-Wilson, C., Boyce, S., Matthies, M., Zandipour M., & Perkell, J. (1999). Articulatory tradeoffs reduce acoustic variability during American English /r/ production. *Journal of the Acoustic Society of America*, *105*, 2854-2865.

NEURAL CORRELATES OF WORD AND SYLLABLE FREQUENCY EFFECTS

Margaret A. Rogers[1], Susan A. McLauglin[1], Dean K. Shibata[2]
[1]*Speech and Hearing Sciences,* [2]*Department of Radiology, University of Washington, USA*
mrogers@u.washington.edu

Introduction

Following the stages of conceptualization and grammatical encoding, spoken language production entails the retrieval of phonological forms accommodated to local phonetic contexts and translated into motor programs that guide articulation. These stages of production from *phonologic encoding through motor programming* (PE-MP) have been difficult to isolate experimentally because their contributions are cumulative, perhaps even interactive, and most measures are temporally insensitive to their fleeting nature. Advances are needed to expand our understanding of these pre-articulatory stages of speech production, in part because the loci of disruption in speech disorders such as apraxia (Rogers & Strokel, 1998; 1999; Rogers & Spencer, 2001), hypokinetic dysarthria (Spencer & Rogers, 2005) and stuttering have all been attributed to processing during PE-MP. Since word and syllable frequency effects have also been attributed to processing during PE-MP (Jescheniak & Levelt, 1994; Andrews & Heathcote, 2001), these effects present an opportunity to investigate the neural correlates of processing during phonologic encoding through motor programming.

Method

The results of two overt speech production experiments employing BOLD fMRI using an event-related design are reported. Twelve monolingual typical American English speakers participated by listening and then repeating real and nonsense words as quickly and accurately as possible every 20 seconds. In Experiment 1, monosyllabic real words served as the stimuli: half high frequency (>100 occurrences/million) and half low frequency (< 7 occurrences/million) (Francis & Kucera, 1982). In Experiment 2, the stimuli consisted of three-syllable nonsense words. Syllable frequency was determined using the CELEX database (The Dutch Centre for Lexical Information: http://www.ru.nl/celex/).

Discussion

Production of high frequency monosyllablic real words resulted in significant bilateral activation in the frontal inferior opercular regions, pars triangularis and orbitalis; production of infrequent monosyllabic words yielded significant activation in the same region but only in the left hemisphere. In fact, no right hemisphere activation was observed during production of low frequency words. Differences between the word and nonsense syllable tasks include a greater magnitude of activation overall for the nonsense syllable task. Interpretation of these results include methodological and theoretical implications for investigating the neural correlates of speech motor control.

References

Rogers, M.A. & Storkel, H.L. (1998). Reprogramming phonologically similar utterances: the role of phonetic features in pre-motor encoding. *Journal of Speech, Language and Hearing Research*, *41(2)*, 258-274.

Rogers, M.A. & Storkel, H.L. (1999). Planning speech one syllable at a time: the reduced buffer capacity hypothesis in apraxia of speech. *Aphasiology*, *13(9-11)*, 793-805.

Rogers, M.A. & Spencer, K.A. (2001). Spoken word production without assembly: Is it possible? *Aphasiology*, *15(1)*, 68-74.

CORTICAL RESPONSES TO FEEDBACK PERTURBATIONS DURING SPEAKING: A MAGNETIC SOURCE IMAGING STUDY

John F. Houde[1], Theda H. Heinks-Maldonado[1], Srikantan S. Nagarajan[2]
[1]Otolaryngology, [2]Radiology, UCSF, San Francisco, CA, USA
houde@phy.ucsf.edu

Introduction

Understanding how speech perception interacts with speech production is a longstanding issue, and one approach to it is to examine how producing speech affects the neural processes serving auditory perception. Several studies have shown that speaking suppresses the normal response to speech sounds in auditory cortex and associated regions. Our own studies suggest that this suppression reflects a comparison between actual auditory input and a prediction of that auditory input (Houde et al., 2002). Based on these initial studies, we have developed a model, derived from modern control theory, for how auditory feedback is processed during speech production. Here, we test this model by looking at cortical responses to feedback perturbations during speaking.

Methods and Results

Using whole-head magnetic source imaging (MSI), we monitored activity in auditory cortex as speakers compensated for brief perturbations of the pitch or amplitude of their speech. Prior studies have shown that such speech perturbations cause compensatory responses in speech motor output (Burnett et al., 1998, Heinks-Maldonado & Houde, 2005). In the speaking session of the experiment, subjects phonated the neutral schwa vowel while sitting in the MSI scanner. At roughly 1.2 second intervals, they experienced 400ms perturbations of the pitch or amplitude of their audio speech feedback. In the listening session of the experiment, subjects passively listened to playback of their audio feedback from the speaking session. Our preliminary results reveal that in most subjects making significant compensations for the feedback perturbations, we find areas in the vicinity of auditory cortex in both hemispheres that have greater responses to the perturbations during speaking than during passive listening.

Discussion

Perturbations in pitch feedback produces the pitch shift reflex (PSR) that has been well researched in psychophysical investigations. However, few studies have directly looked at its neural substrate. The results of this study are important for understanding the neural circuits linking speech perception and production. The results may also have clinical relevance to treating disorders of speech such as the hypophonia seen in Parkinson's disease (Ho et al., 1999), as auditory feedback processing abnormalities may play a role in such disorders.

References

Houde, J.F., et al. (2002) Modulation of auditory cortex during speech: An MEG study. *Journal of Cognitive Neuroscience*, *14(8)*, 1125-38.

Burnett, T.A., et al. (1998) Voice F0 responses to manipulations in pitch feedback. *Journal of the Acoustical Society of America*, *103(6)*, 3153-61.

Heinks-Maldonado, T.H., & J.F. Houde (2005) Compensatory responses to brief perturbations of speech amplitude. *Acoustics Research Letters Online*, *6(3)*, 131-7.

Ho, A.K., et al. (1999) Speech volume regulation in Parkinson's disease: effects of implicit cues and explicit instructions. *Neuropsychologia*, *37(13)*, 1453-60.

GENETIC AND ENVIRONMENTAL INFLUENCES IN STUTTERING AND WHETHER THE GENETIC TRANSMISSION PROCESS IS SEX-MODIFIED

Anna Remington[1], Peter Howell[1], Katharina Dworzynski[2], Robert Plomini[2]
[1]University College London, [2]Kings College London, United Kingdom
a.remington@ucl.ac.uk

Introduction

Stuttering is a disorder characterised by chronic speech dysfluency which undermines normal conversational ability. The condition, seen in more males than females, affects 1% of the population at any one time although 5% are thought to have stuttered at some point. The discrepancy between these values reflects the fact that a large percentage of cases recover without intervention. It is widely accepted that there are genetic components of the trait but the nature of such influences are yet to be confirmed. Within this study, two methods were used to further clarify this genetic component and, more specifically, to address the issues of the unequal sex-ratio and the relationship between persistent and recovered stuttering.

Methods and Results

The first method used family history data from 73 probands and 17 control participants: 1334 and 260 relatives respectively. Probands and controls were tested over the ages of 8 to 14 years and could therefore be accurately assigned to persistent and recovered groups. The second method used data from the Twins Early Development Study (TEDS) which is a large community twin sample from the UK. Data were collected from participants at age 2, 3, 4 and 7 years using questionnaire booklets. Out of 12,892 children, 950 children were classed as recovered and 135 as persistent. The findings from the two experiments show that stuttering has a large genetic component (65% heritability) with the remainder of the variance due to non-shared environmental factors. The trait, while affecting more males than females, does not appear to be sex-modified.

Discussion

Overall, the findings from these two experiments point to a highly heritable condition that is passed through families via a complex model of transmission. Both sets of results dispute the suggested sex-modified pattern of inheritance and conclude that more work is needed to accurately explain the uneven sex-ratio seen in the trait. The heritability of both persistent and recovered stuttering was established, and data suggest that the two types of the disorder arise from a common aetiology with persistence requiring additional genetic factors. The indication that there are genetic influences behind stuttering suggests that research should now focus on more extensive genome investigations. Understanding whether persistent and recovered stuttering are transmitted separately and what familial factors are involved could also help map out early intervention strategies that could be employed.

References

Ambrose, N., Cox, N. & Yairi, E. (1997). The genetic basis of persistence and recovery in stuttering. *Journal of Speech, Language and Hearing Research*, *40(3)*, 567-580.

Kidd, K., Kidd, J., & Records, M. (1978). The possible causes of the sex ratio in stuttering and its implications. *Journal of Fluency Disorders*, *3*, 13-23.

Felsenfeld, S., Kirk, K., Zhu, G., Statham, D., Neale, M., & Martin, N. (2000). A study of the genetic and environmental etiology of stuttering in a selected twin sample. *Behavior Genetics*, *30(5)*, 359-366.

SPEECH ENCODING AS REFLECTED IN PHONOLOGICAL PROCESSING TASKS IN CHILDREN WITH WILLIAMS SYNDROME

Jeffrey A. Marler, Christopher R. Watts
James Madison University, Madison WI, USA
marlerja@jmu.edu

Introduction

Williams syndrome (WS) is a genetic neurodevelopmental disorder, most often accompanied by mild-to-moderate mental retardation. Phonetic/phonological processing is consistently reported as better than expected give the degree of their cognitive impairment (Mervis et al., 1999). It has been suggested that while auditory short-term memory skills are a relative strength in WS (phonetic encoding, digit span and nonword repetition; Majerus et al., 2003), weaker semantic knowledge may be due to an inefficient dependence upon phonological storage abilities. Our purpose was to (a) evaluate auditory sensitivity and phonological processing skills in school-aged children WS and (b) compare them with controls with typically developing language.

Methods and Results

We will report hearing screening and phonological processing data on 20 individuals between the ages of 7 to 19 (M=12;7). A subgroup of individuals with WS ages 8 to 15 (M=11;9), were then compared with age-matched, typically developing children between the ages 9 to 15 (M=11;6).

Hearing: Sixteen out of twenty participants (65%) failed objective measures of auditory function (DPOAEs). The auditory data indicate a mild, high-frequency sensorineural hearing loss in greater than half of the WS participants (Marler et al., 2005).

Phonological Processing: Alternative phonological awareness (APA) performance was stronger than phonological memory (PM) or phonological awareness (PA). And contrary to earlier reports, auditory memory, particularly digit span was not a relative strength in WS.

Discussion

In optimal listening environments, a mild-to-moderate sensorineural hearing loss did not significantly depress phonetic skills. The WS Group performed significantly better with phonology tasks that were independent of semantic knowledge. This data supports the hypothesis that semantic limitations in individuals with WS adversely impact their segmentation, syllable and phoneme deletion abilities. In the WS/Control comparison, participants with WS had markedly depressed PM scores, while their APA scores were similar to control scores. This does not support previous reports (Mervis, 1999; Majerus et al., 2003). Children and adolescents with WS show an inefficient “data driven” auditory information processing strategy.

References

Majerus, S., et al. (2003). An investigation of verbal short-term memory and phonological processing in four children with Williams syndrome. *Neurocase*, *9*, 390-401.

Marler, J.A., et al. (2005). Sensorineural hearing loss in school-age children with Williams syndrome. *American Journal of Medical Genetics Part A*, *8*, 318-327.

Mervis, C.B., Morris, A., Bertrand, J., & Robinson, B.F. (1999). Williams syndrome: Findings from an integrated program of research. In: H. Tager-Flusberg (Ed.) *Neurodevelopmental disorders*, 65-110. Cambridge, MA: MIT Press.

THE INFLUENCE OF THE PALATE SHAPE ON ARTICULATORY TOKEN-TO-TOKEN VARIABILITY

Jana Brunner[1,2,3], Susanne Fuchs[2], Pascal Perrier[3]
[1]*Humboldt-Universität zu Berlin,* [2]*Zentrum für Allgemeine Sprachwissenschaft, Berlin, Germany,* [3]*ICP Grenoble, France*
brunner@zas.gwz-berlin.de

Introduction

It is hypothesized that in order to ensure perception, speakers control the accuracy of their articulatory gestures in relation to the associated variability of the acoustic speech signal. From this perspective; since articulation and acoustics are not linearly related, the range of perceptually accepted articulatory variability is expected to be dependent on the vocal tract configuration: Applying this idea to interspeaker differences, one can expect speakers' articulatory variability to differ in dependence on the shape of their vocal tract's external boundaries. In the present study we investigate the relationship between palate shape, articulatory and acoustic variability.

Methods and Results

The influence of articulatory variability on the acoustic output of /a, i, u/ for five palates differing in coronal shape was tested with a biomechanical tongue model (Payan & Perrier, 1997). The tongue position was changed slightly several times for each vowel. The results show that F1 and F2 vary more for coronally flat palates than for domeshaped ones.

An EPG experiment with 34 speakers was carried out in order to investigate the relation between the palate shape and articulatory variability. The palate shape in the coronal plane was estimated by a parabolic function parameterized with a coefficient alpha (Brunner et al., 2005), which is high for flat palates and low for domeshaped palates. Articulatory variability was measured as the standard deviation of the percentage of contacts. Fig.1 gives the alpha values (top line), and the articulatory variability (solid: non-English subjects, dotted: all subjects). Numbers give variability. Speakers with flat palates tend to show less variability than speakers with domeshaped palates.

Discussion

Our results support perception oriented control of articulatory variability. As shown by the simulations for a given articulatory variability the acoustic output changes more if the palate is flat than if it is dome-shaped. The experiment suggests that speakers control their articulatory variability in dependence on their palate shape. Thinking about the way speech production tasks are represented in the brain our results support a predomi-nance of acoustic representations over gestural ones.

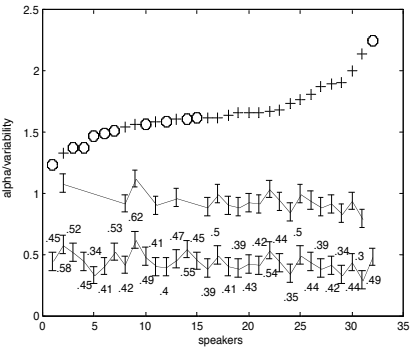


Fig. 1: Experimental results

References

Payan Y. & Perrier P. (1997). Synthesis of V-V Sequences with a 2D biomechanical tongue model controlled by the Equilibrium Point Hypothesis. *Speech Communication*, *22 (2/3)*, 185-205.

Brunner, J., Fuchs, S., & Perrier, P. (2005). The influence of the palate shape on articulatory token-to token variability. *ZAS Papers in Linguistics, 42* :43–66.

TEMPORAL AND SPATIAL ASPECTS IN THE REALISATION OF VOICED AND VOICELESS FRICATIVES IN DIFFERENT WORD POSITIONS

Susanne Fuchs[1], Marzena Zygis[1], Jana Brunner[1,2,3], Christo Velkov[1], Anke Busler[1], Pascal Perrier[2]
[1]Zentrum für Allgemeine Sprachwissenschaft, Berlin, Germany, [2]ICP & INPG Grenoble, France, [3]Humboldt-Universität zu Berlin, Germany
fuchs@zas.gwz-berlin.de

Introduction

The voicing contrast in sibilants' production is particularly challenging concerning the control of voiced fricatives since two different air pressure conditions counteract: a higher subglottal than intraoral pressure for the production of voicing and a higher intraoral than atmospheric pressure for the production of frication. There is only a very narrow region where both conditions can be realised, otherwise phonologically voiced sounds often become devoiced. We will therefore investigate temporal and spatial production mechanisms potentially involved in the control of the voicing contrast in fricatives. Different word positions will be considered since German shows specific phonemic inventory restrictions with respect to word positions. In addition, we will compare data from German speakers with other languages exhibiting no positional restrictions (Bulgarian) or a richer fricative inventory than German (Polish).

Methods and Results

By means of Electropalatography (EPG) and acoustics we recorded 5 German, 2 Polish and 2 Bulgarian subjects. The word material consisted of real words embedded in a carrier sentence with /s, z, ʃ, ʒ/ (German, Bulgarian) and /s, z, ɕ, ʑ, ʂ, ʐ/ (Polish) in word initial stressed position, in word internal unstressed position, and in word final stressed position. Results for frication and voicing duration provide evidence that the former parameter is more stable than the latter for German subjects coming from different regions of Germany. Especially the South German subjects devoice phonologically voiced phonemes, but maintain differences in frication duration with longer durations for the voiceless sounds. Bulgarian and Polish speakers' data clearly show differences with respect to both temporal parameters, except for the word final position. In general, sounds which are realised as voiced exhibit more tongue palatal contacts (anterior index) due to a smaller medial tongue groove. The amount of anterior contact correlates positively with voicing duration.

Discussion

In accordance with Dixit and Hoffman (2004) we suggest that building a narrower tongue groove in voiced sibilants is one control strategy to allow voicing and frication. The narrow channel is responsible for an increase in airflow (to produce frication) although the glottis is slightly open or closed (to produce voicing). The realisation of a small constriction channel maybe particularly sensitive to distortions and therefore be one reason why patients suffering from sensori-motor coordination problems have most difficulties to produce these sounds.

References

Dixit, R.P. & Hoffman, P.R. (2004). Articulatory characteristics of fricatives and affricates in Hindi: an electropalatographic study. *Journal of the International Phonetic Association*, *34(2)*, 141-159.

PHYSIOLOGIC DEVELOPMENT OF TONGUE-JAW COORDINATION

Bruce E. Murdoch, Yan Cheng, Justine V. Goozée
Motor Speech Research Unit, The University of Queensland, Australia

Introduction

The precise coordination of articulator motions in time and space is critical for even the simplest speech output. From the perspective of classical motor control theories, adults have organized functional synergies that act as stable subunits to promote consistent patterns of muscle activation during speech production. The present study aims to describe the development of the tongue-jaw functional synergy for speech motor coordination from childhood to adolescence.

Methods and Results

The electromagnetic articulography (EMA) was used to track tongue (-tip and -body) and jaw motion during /t/ and /k/ productions in 48 children and adults (aged 6-38 years). The dynamic interactions of the tongue and jaw and the stability of this relationship was investigated by computing the tongue-jaw movement onset and maximum velocity time lag, spatial-temporal coupling and variability indices, and the tongue-jaw velocity ratio.

For /t/ production, statistical analyses revealed a linear relationship in the maximum velocity time lag values achieved across the age groups, supporting a general increase of temporal coupling with maturity. Moreover, the 6- to 7-year-olds achieved mean lag time values significantly longer than the older participants. For /k/ production, a linear relationship was identified for the variability index, indicating a trend of reducing variability of coordination with age. The 6- to 7-year-olds, in particular, were significantly more variable in their coordination patterns than the adults.

Discussion

Major findings of the study include: (a) The first signs of a mature synergy were observed in the 8- to 11-years age group; their tongue-tip to jaw temporal coupling largely reflected that seen in adults, and while movement synchrony did not significantly change between the tongue-body and jaw, their coordination patterns had reached an adult-like level of consistency, (b) the tongue-jaw synergy continued to undergo subtle changes into late adolescence, (c) development of the synergistic relationship between the tongue-tip and tongue-body with the mandible is not the same; while tongue-tip movement becomes more securely supported by jaw movement, tongue-body and jaw retain movement independence but develop consistency in their dynamic relationship. The present results support the notion that speech motor development is nonuniform, with a refinement period in tongue-jaw coordination from mid-childhood to late adolescence.

References

Kent, R.D., Adams, S.G., & Turner, G. (1996). Models of speech production. In: N.J. Lass (Ed.) *Principles of Experimental Phonetics*, 3-45. St. Louis: Mosby.

Smith, A. & Zelaznik, H.N. (2004). Development of functional synergies for speech motor coordination in childhood and adolescence. *Developmental Psychobiology*, *45(1)*, 22-33.

INTERGESTURAL TIMING AND SPEAKING RATE: AN EPG STUDY OF PALATAL AND PALATALISED CONSONANTS IN JAPANESE

Mitsuhiro Nakamura
Nihon University, Tokyo, Japan
m-nakamura@eco.nihon-u.ac.jp

Introduction

Languages differ in their system of contrast. This design property, as pointed out by various studies, constrains the articulatory activities in the vocal tract. The present study focuses on consonantal articulations which are allophonic in one context but are contrastive in another. An investigation involves the spatiotemporal pattern of intergestural coordination across changes in speaking rate in the production of palatal(ised) consonants.

Previous studies have shown that palatal(ised) segments differ from language to language in the nature and extent of the involvement of the tongue-dorsum raising gesture. In Japanese palatal(ised) consonants appear before the front vowel /i/ (CiV syllables) and before non-front vowels /a, o, u/. The latter cases are phonologically contrastive, being analysed as /Cj/ (CjV syllables). An attempt was made, using electropalatography, to determine whether the palatals in the distinct syllable types are characterised by different articulatory patterns; and how the phonological contrast and a speech-rate contrast are related.

Methods and Results

The experiment examined the four consonants that differ in places and manners of articulation and in phonological status: [ɲ], [ɕ], [r^j], and [k^j]. The speech items consisted of /a/C/i/, /a/Cj/a/, and /a/Cj/u/ words. Two native speakers of standard Japanese produced the test sentences at normal speed. One produced the same sentences at self-selected fast speed.

The analysis of the normal-speed tokens showed that the spatial configurations, similar between the consonants in CiV and CjV syllables, are derived from the contrastive temporal coordination between the two components of the tongue. The normal-fast comparison revealed that an increase in speaking rate shortened the overall duration and that the reduction ratios of the fast-speed tokens were specific to the consonant types. Nevertheless, the contrastive timing of the dorsum gesture was maintained systematically.

Discussion

The results suggest that, while variations in speaking rate have differential effects on the spatiotemporal properties of articulatory gestures, the timing patterns vary systematically as a function of the phonological status of the consonants in question. It appears that a speaker employs two contrastive timing strategies and manifests the robust temporal patterns across different speaking rates, maintaining the integrity of phonological structure.

References

Browman, C.P. & Goldstein, L. (1992) Articulatory Phonology: an overview. *Phonetica*, *49*, 155-180.

Byrd, D. (1994) Articulatory Timing in English Consonant Sequences. *UCLA Working Papers in Phonetics*, *86*, 1-196.

Recasens, D. (1984) Timing Constraints and Coarticulation: Alveolo-Palatals and Sequences of Alveolar + [j] in Catalan. *Phonetica*, *41*, 124-139.

A TASK DYNAMIC MODEL OF TONGUE MOTION

Khalil Iskarous
Haskins Laboratories, New Haven, USA
iskarous@haskins.yale.edu

Introduction

The task dynamic model of speech production explains how the discrete context-invariant units of linguistic contrast are realized as continuous, coarticulated speech (Saltzman & Munhall, 1989). The model consists of a set of differential equations that describe the dynamics of the tasks and coordinate transformations that translate from the dynamics to the motion of individual articulators. We propose a model of tongue motion within task dynamics that is able to model lingual transitions more accurately than the original model.

At the gestural level, we propose that the dynamics is represented by a linear partial differential equation of second order, which describes the change of the value of the area function in time and space. The equation is $\frac{\partial^2 A}{\partial t^2} = \omega \frac{\partial^2 A}{\partial x^2}$, i.e. the acceleration of the area function at any point in the vocal tract is proportional to the "curvature" of the area function and the stiffness, which is prosodically determined.

Methods and Results

Data will be presented from an X-ray study of 600 lingual transitions in English and French that confirm the predictions of that model (Iskarous, 2005). The partial differential equation for area function change proposed is shown to predict 84% of the data anlyzed In addition a new model of the tongue at the articulatory level is proposed. The tongue body is usually modeled as the arc of a circle. Instead, we model the two dimensional edge of the tongue as a deforming continuum paramaterized by the position and curvature at each of its points. Kinematic transformations then translate from the area function coordinates to the curvature. X-ray microbeam data is then used to show that lingual transitions modeled at the gestural level using the partial differential equation and at the articulatory level using the curvature-parametrized curve to highly accurate.

Discussion

Previous models of the tongue within the task dynamic framework model the tongue as a tongue body circle and a tongue tip circle joined by a curve. At the gestural level, lingual segments are modeled as having either tonge body or tongue tip gestures(Saltzman & Munhall, 1989; Nam et al., 2004). The continuum model of the tongue proposed in this paper is empirically more accurate than the original model, but when discretized, yields the basic second order equations of the original model.

References

Iskarous, K. (2005). Patterns of tongue movement. *Journal of Phonetics*, *33 (4)*, 363-381.

Nam, H., Goldstein, L., Saltzman, E., & Byrd, D. (2004). TADA: An enhanced, portable Task Dynamics model in MATLAB, *Journal of the Acoustical Society of America*, *115(5)*, 2430.

Saltzman, E. & Munhall, K. (1989). A dynamical approach to gestural patterning in speech production. *Ecological Psychology*, *1*, 333-382.

HOW WELL CAN DIADOCHOKINETIC RATE PREDICT RATE OF SPEECH?

Ying-Chiao Tsao
Department of Human Communication Studies
California State University, Fullerton, CA, USA
ytsao@fullerton.edu

Introduction

Diadochokinesis (DDK) is a performance test of speech production used to examine the upper limits of speech motor behavior (Kent et al., 1987). Tiffany (1980) suggested DDK rate as a measure of articulation due to its simplicity in terms of phonological structures. However, using DDK rates to predict speech rates remains debatable since the stress patterns of syllables for these two tasks are not the same (Forrest, 2002). According to Kent et al. (1987), a serious obstacle for using DDK tasks for general clinical application of maximum performance measures was that such measures lacked a substantial theoretical base and standardized procedures for the quantification of DDK rates. This study aims to examine the predictive relationships between habitual and maximal DDK rates, in comparison to speech/articulation rates of *Slow* and *Fast* talkers.

Methods and Results

Thirty participants (15 *Slow*, 15 *Fast* talkers) were asked to perform a DDK task (i.e., /puh-tuh-kuh/) at both habitual and maximum rates. DDK rate was calculated based on a 2-second interval of the middle portion of a 5-second sample. The average *habitual* DDK rate was 4.79 ± .84 syllables per second for the *S*low group, and 5.12 ± 1.21 syllables per second for the *F*ast group. The average *maximum* DDK rate was 6.87 ± .69 syllables per second for the *S*low group, and 7.47 ± .8 syllables per second for the *F*ast group. Only a small percentage of accountable variance (R^2<35%) was found for the predictive ability of habitual DDK rates to their maximum DDK rates; in addition, Pearson product moment correlation coefficients between DDK rates and speech/articulation rates were only .26 to .65.

Discussion

Although significant regression functions between maximum and habitual DDK rates were obtained for both the *S*low and the *F*ast group, the study findings failed to show a strong predictive relationship between DDK and articulation rates. The study findings therefore support the assertion that study of DDK task does not reveal the true nature of speech motor process and disorder (Weismer, in press). As indicated by Chang and Hammond (1987), articulatory and diadochokinetic movements may be functionally different in nature. Moreover, according to Tsao and Weismer (1997), *Slow* and *Fast* talkers exhibited significantly different manipulation of their speech/articulation rates. The discrepancy that existed between the speech and DDK tasks in their predictability may therefore be explained.

References

Kent, R.D., Kent, J.F., & Rosenbek, J.C. (1987). Maximum performance tests of speech production. *Journal of Speech and Hearing Disorders, 52*, 367-387.

Weismer, G. (in press). Philosophy of research in motor speech disorders. *Clinical Linguistics and Phonetics*.

HOW DOES THE GLOTTIS BEHAVE IN VOICELESS SENTENCES?

Rachid Ridouane[1], Susanne Fuchs[2], Phil Hoole[3]
[1]*Laboratoire de Phonétique et Phonologie, Paris, France,*
[2]*Zentrum für Allgemeine Sprachwissenschaft, Berlin, Germany,*
[3]*Institut für Phonetik und Sprachliche Kommunikation, München, Germany*
rachid.ridouane@wanadoo.fr

Introduction

One of the most important challenges in the study of speech production is to gain a theoretical understanding of how laryngeal and supralaryngeal movements are coordinated during speech, and to determine which factors influence this coordination. Although consonant sequences are of special importance in understanding articulatory organization, little articulatory data have been published on such sequences.

Tashlhiyt Berber, spoken in the southern part of Morocco, allows an unusually rich combination of voiceless sounds and presents a typologically unique phenomenon: words may have no vowel or vowel-like segments and may consist entirely of voiceless obstruent consonants (t-kks-t=stt " *you took it off"*). A whole sentence may also be entirely voiceless (t-ftk-t=stt t-fk-t=stt " *you sprained it and gave it"*).

Method

Laryngeal and supralaryngeal adjustments during the production of such forms are examined by means of simultaneous transillumination, fiberoptic films and acoustic recordings. The data analyzed consisted of 24 voiceless words and 4 voiceless sentences. Each word and sentence was repeated 7 times by two male native speakers. Only data from one subject have been analyzed so far.

This study focuses on the number and the location of glottal opening peaks during different forms and examines the mechanisms which might determine the adjustments observed.

Results

Results show that the glottis does not simply remain open for these voiceless words and sentences, but rather that the glottal aperture is continuously modulated in a manner that can be related quite systematically to the individual segments in the voiceless sequences. Glottal opening during the production of these forms is characterised by a one-, two, three, or more than three-peaked pattern according to the nature of the voiceless obstruents and the way they are combined. A good predictor of the number of glottal opening gestures occurring is that in a voiceless sequence, each fricative and geminate stop, unless adjacent, requires a single separate glottal abduction.

The variation in laryngeal adjustments is related to segmental properties of a sequence. Voiceless geminate stops and fricatives, requiring a high rate of oral airflow and build-up of oral air pressure, are produced with a separate glottal opening gesture. These results are in general agreement with those obtained using the same method on voiceless fricative-stop clusters separated by word boundaries (Ridouane et al., 2006).

References

Ridouane, R. Fuchs, S., & Hoole, P. (2006). Laryngeal adjustments in the production of voiceless obstruent clusters in Berber. In: J. Harrington & M. Tabain (Eds.) *Speech Production: Models, Phonetic Processes, and Techniques*, 257-297. Macquarie University: Sydney, Australia.

ON THE SYNCHRONISATION OF ARTICULATORY GESTURES WITH ACCENTUAL F0 PEAKS

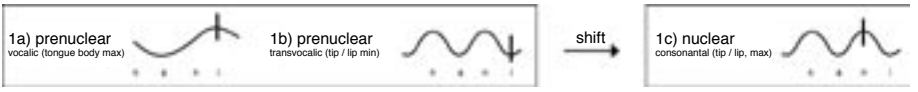
Doris Mücke, Martine Grice
IfL Phonetik, University of Cologne, Germany
doris.muecke@uni-koeln.de

Introduction

We report on a production experiment investigating the temporal synchronisation of F0 peaks in rising pitch accents with landmarks in the acoustic and kinematic signals. We explore how peaks in F0 corresponding to H tones in L+H* pitch accents are temporally aligned with landmarks of acoustic *segments* (e.g. CV boundaries) and with landmarks of dynamically defined articulatory *gestures* (Browman & Goldstein, 1988). Acoustic studies have shown that the status in the intonational hierarchy of pitch accents can affect the alignment of the corresponding F0 peak (e.g. Schepman, et al., 2006, for Dutch). Here we investigate the effect of pitch accent on acoustic and articulatory alignment in German.

Methods and Results

Two speakers of the Düsseldorf variety read meaningful sentences constructed so as to systematically vary (i) accent status, (ii) articulation rate (normal and fast) and (iii) syllable structure in the accented syllable (CV: and CVC). Recordings were carried out using EMMA, with sensors placed on lower lip, tongue tip and tongue body. Time stamps of turning points in the F0 contour were compared with landmarks in the acoustic and kinematic signals. We found tonal targets to be more tightly synchronised in time with articulatory movements than with segment boundaries. There was a clear effect of accent status but no effect of (ii) or (iii). *Prenuclear*: The peak occurs during the vowel of the unstressed syllable [mi] or [ni] following the accented syllable [ma] or [na], and coincided with landmarks of oral gestures for this vowel (target of vocalic tongue body raising and transvocalic minimum of tip/lip closure, fig.1a-b). *Nuclear:* The peak occurs during the intervocalic consonant. It aligns consistently with the target of the consonantal lip/tip gesture (fig.1c) corresponding to this consonant.



Discussion

A target shift was found between nuclear and prenuclear accent alignment. In the acoustic domain, the H peak was shifted from a vocalic segment to the preceding consonant, although no specific acoustic anchor (onset or offset of segment) was found to predominate. In the articulatory domain alignment was more stable across articulation rate and syllable structure, and the target was shifted from one articulatory gesture to another (fig. a,c). We could reinterpret these results as involving an alignment shift from one state in the virtual cycle of a single dynamical gesture to another, such as the onset of a primary constrictor's movement of the tongue tip or lower lip to the achievement of a respective goal.

References

Browman, C.P. & Goldstein, L. (1988). Some Notes on Syllable Structure in Articulatory Phonology. *Phonetica*, *45*, 140-155.

Schepman, A., Lickley; R., & Ladd, D.R. (2006). Effects of vowel length and "right context" on the alignment of Dutch nuclear accents. *Journal of Phonetics, 34(1)*, 1-28.

PROSODIC EFFECTS ON ARTICULATORY MOVEMENTS AT PHRASE BOUNDARIES IN SPONTANEOUS SPEECH

Patrizia Bonaventura
Department of Communication Sciences, Case Western Reserve University, Ohio, USA
patrizia.bonaventura@case.edu

Introduction

The present study aims to investigate whether phrase-final lengthening affects 'icebergs', defined by the C/D model (Fujimura, 2003) as stable patterns that have been shown to maintain their robustness in different prosodic environments (Fujimura, 1996). Previous studies (Bonaventura, 2003) have shown evidence in favor of the existence of 'iceberg' patterns, but a linear dependence of slope on the total excursion of the demisyllabic movement appeared, instead of the predicted constancy of speed at iceberg threshold crossing. Systematic outliers from the linear dependence of slope on excursion, suggested that the presence of a following long boundary might have induced "phrase-final elongation". This lengthening effect is geenrally manifested by an increased acoustic syllable duration and a decreased jaw opening, so that the iceberg crossing speed of the crucial articulator in the final demisyllable may be consequently slowed down.

Previous studies on read data (Bonaventura & Fujimura, 2004) from a corpus of simulated dialogues have shown no significant effect of syllable magnitude and boundary strength on iceberg speed, probably due to the read nature of the dialogues, not allowing for relevant variations in excursion at phrase boundary. The aim of this study is to verify whether the elongation effect can be identified and isolated in utterances presenting a larger variety of prosodic conditions because occurring in a more natural conversational context.

Methods and Results

The data observed represent the speed of movement of a flesh-point on the tongue blade or the lower lip as the crucial articulator of the observed consonant, when the flesh point crosses a fixed vertical position (iceberg threshold) relative to the occlusal plane.

Results show a deviation from the linear dependency patterns described above, in phrase final position; however, two of the speakers considered show a slower speed with respect to excursion values, whereas two of the speakers show a tendency to increase speed.

Discussion

These results agree with previous studies on the Blue Pine corpus (Menezes, 2003) which found different strategies of adjustment to following long phrase boundary. The effect supports the hypothesis of the existence of an influence of articulatory gap on preceding syllable duration and magnitude, and the systematic presence of this effect in our data.

The variation in the results in terms of slope, however, prospects greater difficulty in modeling iceberg patterns, as predicted models of iceberg curves seem to have to take into account subjective factors in the realization of muscle trajectories in syllable final position before phrase boundary.

References

Bonaventura, P. (2003) 'Invariant patterns in articulatory movements', PhD Dissertation, The Ohio State University.
Fujimura, O. (2003) 'Temporal organization of speech utterance: a C/D model perspective', *Cadernos de Estudos Lingüísticos*, *43*, 9-35.
Fujimura, O. (1996) 'Icebergs revisited', ASA Meeting, 2aSC.

STIFFNESS REGULATION IN SPEECH MOVEMENTS

Rafael Laboissière[1,2], Daniel Lametti[3], David J. Ostry[3,4]
[1]*Max Planck Institute for Human Cognitive and Brain Sciences, Munich, Germany,*
[2]*CNRS, France,* [3]*McGill University, Montreal Canada,*
[4]*Haskins Laboratories, New Haven USA*
laboissiere@cbs.mpg.de

Introduction

The idea that speech involves precise and finely timed patterns of movement is a usual assumption in speech production research. Here we report a test of this idea in the context of measures of jaw stiffness. Stiffness is a quantitative measure of resistance to displacement. Stiffness is known to be high in directions where variability and presumably precision is low and vice versa (Shiller et al., 2002). To the extent that speech production involves a precise regulation of variability, stiffness should be higher in speech than in matched non-speech movements.

Methods and Results

We estimated jaw stiffness during movement using a new technique in which a robotic device applies forces to the jaw during movement. The problem in estimating stiffness during movement is that it is necessary to have measures of both a perturbed trajectory and what the trajectory would have been in the absence of load. We have estimated this "reference trajectory" using a technique based on Fourier analysis. An autoregressive (AR) model was used to fit the deviations from the reference trajectories for both positions and forces. In this model, the deviations in force are linearly predicted by the past values of deviations in position. The stiffness matrix is obtained from the steady-state of the AR model. We applied this technique to data from 22 subjects whose jaw movements were perturbed during simple speech utterances and matched non-speech movements. We observed no systematic difference in stiffness in the speech and non-speech conditions.

Discussion

We report somewhat surprising evidence that the stiffness of the jaw is in fact no different in speech production than in non-speech movements that are matched in duration and movement amplitude. This is a result that is based on a large number of subjects and hence we feel we have ample statistical power to find a difference had there been one. The absence of any observed differences in jaw stiffness between speech and non-speech conditions points to the idea that in spite of the apparent complexity of speech production, it would seem that there is nothing out of the ordinary about speech movement precision.

References

Shiller, D.M., Laboissière, R., & Ostry, D.J. (2002). The relationship between jaw stiffness and kinematic variability in speech. *Journal of Neurophysiology*, *88*, 2329-2340.

A LONGITUDINAL INVESTIGATION OF DEVELOPMENT OF EARLY SPEECH MOTOR CONTROL IN TYPICALLY DEVELOPING INFANTS

Heidi Diepstra[1,2], Pascal van Lieshout[1,2], Alice Eriks-Brophy[2] & Ben Maassen[3]
[1]Oral Dynamics Laboratory, [2]Department of Speech and Language Pathology, University of Toronto, Canada, [3]Radboud University Medical Centre, Nijmegen, The Netherlands.
H.Diepstra@utoronto.ca

Short Overview

Most children acquire the complex skills involved in speech production rapidly and start to produce simple sentences within the first two years of life. Several studies have analyzed the normal development of speech production in detail (see Clements (2004), for a review), and there is general agreement on a stage-like developmental course in which early speech production moves progressively from vocalizations through the stages of canonical and variegated babbling to the production of the first meaningful words. These studies, however, are often based on perceptual analyses, are mainly descriptive in nature, and only picture the stable "end states" of speech development, not the processes that lead to a change from one stage to another. To reveal the speech developmental pathway we propose an alternative research approach, inspired by the work of Thelen (1995) on the development of walking in infants.

Infants show variability in the onset of the different stages of speech development that is unexplained so far. What theoretical framework accounts for both individual variability and the emergence of a general behavioural pattern in speech development? In studies on the development of walking in infants, Thelen and colleagues showed how locomotion is not a motor activity scripted by maturational or cognitive processes, but rather assembled from subsystems that are changing over time in interaction with the environment. Like locomotion, speech may be considered as a dynamical system, and, if so, can be characterized by periods of stability and instability.

In the current longitudinal research study, stabilities (attractor states) and instabilities (phase shifts) in the development of orofacial motor control in infants as young as 4 months of age will be tracked to identify the potential control parameters that shape this development. To date, few studies have examined speech motor control in infants at this very young age, and it remains unclear whether goal directed speech movements emerge from spontaneous oral motor behaviours such as non-nutritive sucking or chewing.

In the proposed study, kinematic recordings of oral and facial structures will be collected simultaneously with acoustic recordings and behavioral observations at frequent measurement intervals from these young infants. The nature and stability of movement coordination will be examined using concepts and tools stemming from dynamical systems theory (DST; Van Lieshout, 2004), including measures of relative phase and spectral coherence. The current presentation will contrast previous work on speech production in infants to the DST perspective on developmental aspects of motor control.

References

Clements, C.J. (2004). *Development of vocalization in deaf and normally hearing infants*. LOT Dissertation series 100, The Netherlands.

Thelen, E. (1995). Motor development: a new synthesis. *American Psychologist*, *50 (2)*, 79-95.

Van Lieshout, P. (2004). Dynamical systems theory and its application in speech. In: B. Maassen, R. Kent, H. Peters, P.van Lieshout, & W. Hulstijn (Eds.) *Speech Motor Control in Normal and Disordered Speech*, 51-82.

ARTICULATORY COMPENSATION TO LABIAL PERTURBATIONS IN CHILDREN AND ADULTS

Jérôme Aubin, Lucie Ménard, Johanna-Pascale Roy, Anthony Calabrino
Université du Québec à Montréal, Canada
jerome.aubin@gmail.com

Introduction

This study aims at describing motor equivalence strategies adopted by children and adults when vocal tract geometry is perturbed by the insertion of a tube between the lips. As this phenomenon of motor equivalence has not yet been studied in children from both acoustic and articulatory points of view, results will shed light on the issue of the speech task representation and speech motor control development in children.

Methods and Results

Four children from 5 to 7 years of age and four adults (all native speakers of French) were recorded. High French vowels [i], [y] and [u] were perturbed by inserting small diameter lip tubes (for [i]) and large diameter lip tubes (for [y] and [u]) between the speakers' lips. For each vowel, acoustic and articulatory (ultrasound imaging) recordings of the speakers' productions were conducted in three conditions: 1) before lip-tube insertion, 2) with the lip-tube inserted between the lips, and 3) after removal of the tube. In each condition, speakers had to pronounce ten repetitions of the isolated vowel.

Results show that all subjects were able to produce vowels in lip-tube condition that were better or as good in quality that those produced before the insertion of the tube. However, differences in the patterns of acoustic and articulatory data in the perturbed condition were observed between children and adults. None of the speakers was able to compensate for the three vowels, which confirms that articulatory compensation is in part selective.

Discussion

A perceptual study revealed that producing a complete compensation does not necessarily involve a modification of acoustic parameters F1, F2 and F3. Indeed, it was found that fundamental frequency is sometimes related to the perceived quality of the vowels, but the change in this parameter is vowel-dependent. Thus, its contribution to supraglottal articulatory compensation needs further investigation, as it plays a key role in the quality of the vowels produced.

The representation of the speech task seems to be both an acoustic and an articulatory one, primarily guided by the acoustic modality. Results shed light on the issue of the role of feedback on the speech production processes.

References

Ménard, L., Perrier, P., & Savariaux, C. (2004). "Exploring production-perception relationships during speech development : a study of compensation strategies to a lip-tube perturbation". *Journal of the Acoustical Society of America*, *115 (5) Pt. 2*, 2629.

Savariaux, C., Perrier, P., & Orliaguet, J.-P. (1995). "Compensation strategies for the perturbation of the rounded vowel [u] using a lip tube: A study of the control space in speech production," *Journal of the Acoustical Society of America*, *98 (5) Pt.1*, 2428-2442.

ACOUSTIC, AERODYNAMIC, AND ARTICULATORY CORRELATES OF CONTRASTIVE FOCUS IN FRENCH CHILDREN AND ADULTS

Lucie Ménard, Jérôme Aubin, Johanna-Pascale Roy, Annie Leclerc, and Mélanie Thibeault
Laboratoire de phonétique, Université du Québec à Montréal, Canada
menard.lucie@uqam.ca

Introduction

In a previous study (Ménard et al., to appear), we showed that the effects of contrastive focus on lip area values and formant values in French are smaller for 4-year-old and 8-year-old children compared to adults. Since in typically-developing children, the lingual and labial articulators are controlled at different stages during development, it is possible that different lingual articulatory strategies are also involved in prosodic marking for adults and children. This study was designed to further investigate production differences between children and adult French speakers in marking focus-induced prominence at the articulatory, aerodynamic, and acoustic levels.

Methods and Results

The corpus consisted of [bVb] syllables, where V is one of the vowels [i a u]. Target words were embedded in carrier sentences elicited in two prosodic conditions: neutral (unfocused) and under contrastive focus. Four 4-year-old children and four adult speakers (all native speakers of French) pronounced ten repetitions of each sequence. The audio signal, tongue shapes and intraoral pressure (IOP) were recorded using a SONOSITE 180 ultrasound and the PCQUIRER aerodynamic system. Formant frequencies, RMS values, and tongue contours for each vowel were extracted. For each consonant, maximal IOP (IOP_{max}) and tongue contours corresponding to IOP_{max} were also measured. Analyses show that prosodic context has a significant effect on acoustic data for [a], with two adults and one child increasing F1 values under contrastive focus, compared to the neutral context. However, this stable acoustic pattern is achieved by various articulatory strategies across subjects (lowering or fronting of the tongue body). Results for /i/ and /u/ show great between-speaker variability. RMS values (for vowels) and IOP_{max} (for consonants) are significantly increased in focused syllables for the adult group only.

Discussion

Articulatory and aerodynamic data show that focused syllables are less differentiated from their unfocused counterparts in children than in adults. Furthermore, at the articulatory level, it is found that b-vowel coarticulation is greater in children than in adults. We interpret these results as evidence of motor-based constraints shaping early prosodic forms (Goffman & Malin, 1999).

References

Ménard, L., Loevenbruck, H., & Savariaux, C. (to appear).Articulatory and acoustic correlatesof contrastive focus in French: a developmental study. In: J. Harrington & M. Tabain (Eds.) *Towards a better understanding of speech production processes.* New York: Psychology Press.

Goffman, L. & Malin, C. (1999). Metrical effects on speech movements in children and adults. *Journal of Speech, Language, and Hearing Research*, *42*, 1003-1115.

VOICE F0 RESPONSES TO PITCH-SHIFTED VOICE FEEDBACK DURING ENGLISH SPEECH

Charles R. Larson[1], Stephanie Chen[1], Yi Xu[2], Kaavya Paruchuri[1], Hanjun Liu[1], Christine Lin[1]

[1]*Department of Communication Sciences and Disorders, Northwestern University, Evanston, USA,* [2]*Department of Phonetics and Linguistics, University College London, United Kingdom*

clarson@northwestern.edu

Introduction

Previous studies using the pitch-shift technique have demonstrated that the control of voice fundamental frequency during sustained vowels, glissandos, non-sense words and Mandarin speech is dependent in part on auditory feedback. The finding of large responses to pitch-shifted feedback in Mandarin speech, a tonal language, was indicative of the need for accurate control of voice F0 during this language. To date, no published studies have demonstrated responses to pitch-shifted feedback in English, a non-tonal language. However, it might be assumed that accurate control of voice F0 during stressed syllables would be important and may rely in part on auditory feedback.

Methods and Results

In the present study, comparisons of responses to pitch-shifted voice feedback during speech were made with responses recorded during a non-speech task (vowel production). Twenty English speakers received pitch-shifted voice feedback (50, 100 or 200 cents; 200 ms duration) while repeating a phrase in a question intonation . Data were digitized (10 kHz, 12 bit) and analyzed off-line by first extracting a voice F0 contour using Praat. Event-related averaging techniques were used to calculate an average response for each condition. In a second condition, subjects sustained a vowel and were presented with the same pitch-shift stimuli.

Responses produced during speech were roughly twice as large (mean 38 cents) as those produced during the vowels (mean 20 cents). Moreover, during speech, response magnitudes increased as a function of stimulus magnitude across the three stimulus values, whereas during vowels, there were no differences in response magnitude as a function of stimulus magnitude.

Discussion

The results suggest that control of voice F0 during English speech depends on auditory feedback, just as in Mandarin. The dependence of the response on stimulus magnitude in speech but not in sustained vowels indicates that in speech, pitch control is goal oriented and thus the vocal control system is sensitive to the magnitude of the error in the feedback signal.

References

Donath, T.M., Natke, U., & Kalveram, K.T. (2002). Effects of frequency-shifted auditory feedback on voice f_0 contours in syllables. *Journal of the Acoustical Society of America*, *111(1)*, 357-366.

Jones, J.A. & Munhall, K.G. (2002). The role of auditory feedback during phonation: Studies of mandarin tone production. *Journal of Phonetics*, *30*, 303-320.

Xu, Y., Larson, C., Bauer, J., & Hain, T. (2004). Compensation for pitch-shifted auditory feedback during the production of mandarin tone sequences *Journal of the Acoustical Society of America*, *116(2)*, 1168-1178.

AERODYNAMIC VALIDATION OF PERCEPTUALLY-BASED BREATH GROUP DETERMINATION

Yu-Tsai Wang[1], Ray D. Kent[2], Ignatius, Nip[3], Jordan R. Green[3], Jane F. Kent[2]
[1]School of Dentistry, National Yang-Ming University, Taipei, Taiwan; [2]Waisman Center, University of Wisconsin-Madison, WI, USA; [3]University of Nebraska-Lincoln, NE, USA
yutsaiwang@ym.edu.tw

Introduction

The clinical and experimental analysis of speech has frequently relied on the identification of breath groups in continuous speech. The locations of inspiration in speech has been typically determined through listening. Although the reliability of perceptually-based breath group determination has been reported to be satisfactory, the validity of perceptual analysis is not known. The purposes of this study are to report the reliability and validity of perceptually determined inspiratory locations and to analyze breath group structure based on physiological inspiratory locations to provide information for the study of speech prosody.

Methods and Results

While wearing a circumferentially vented mask connected to a pneumotach, 16 participants read two passages and answered six questions. Airflow traces were used to locate points of inspiration during each continuous speech sample. To determine the validity of perceptually based identification of breath-group, the perceived locations of inspiration -with agreement for at least two of the three judges - were compared to the actual locations of inspiration. The results indicated that the reliability and validity of perceptual analysis were satisfactory for both tasks; furthermore, the error rate of perceptual analysis in conversation was significantly smaller than in passage reading. The number of inappropriate locations, breath group duration, and ratio of breath group duration to inspiratory duration were significantly larger and longer for the conversation task than for the passage reading task, but no task differences for inter-breath-group pause and inspiratory duration were found.

Discussion

The satisfactory reliability and validity of perceptually-based breath group determination indicated that the clinical practice of perceiving pause or inspiratory locations and the rule of breath group determination suggested by previous studies are satisfactory. One possible reason that 12% of inappropriate inspiratory locations did not affect speech intelligibility is that none of them occurred within-word. Moreover, heavier cognitive loading and more efforts on coordinating inspiratory locations into grammatical structure in conversations than in passage reading might partly explain the differences in breath group structure between tasks.

References

Kent, R.D. & Read, C. (2002). *The Acoustic Analysis of Speech*. San Diego, California: Singular.

Wang, Y.T., Kent, R.D., Duffy, J.R., & Thomas, J.K. (2005). Dysarthria in traumatic brain injury: a breath group and intonational analysis. *Folia Phoniatrica et Logopaedica*, *57*, 59-89.

SOMATOSENSORY, AUDITORY, AND MOTOR REPRESENTATIONS IN A NEURAL MODEL OF SPEECH PRODUCTION

Bernd J. Kröger[1], Peter Birkholz[2], Jim Kannampuzha[1],
Christiane Neuschaefer-Rube[1]
[1]Department of Phoniatrics, Pedaudiology, and Communication Disorders, University Hospital Aachen, [2]Department of Computer Science, University of Rostock, Germany
bkroeger@ukaachen.de

Introduction

Quantitative computer implemented neural models of speech production – comprising a high quality front-end articulatory speech synthesizer – are rare (e.g. Guenther & Perkell 2004). The Aachen neural model of speech production is discussed here focussing on modeling the somatosensory, auditory, and motor representation.

Methods and Results

In this approach the somatosensory representation comprises neural maps for tactile information (i.e. neurons representing contact patterns of the lower with the upper lip and of the tongue with the vocal tract walls) and for proprioceptive information (i.e. neurons representing flesh-point locations in the cranial coordinate system). The auditory representation comprises neural maps for quasi-static information (i.e. neurons representing static formant patterns) and for motional information (e.g. neurons representing transitional formant patterns). In addition two levels of motor representations – i.e. a spatial coordinate and a joint coordinate level – are implemented.

The babbling and imitation phase of speech acquisition can be simulated using our high quality three dimensional articulatory speech synthesizer (Birkholz & Jackel 2003) as a front-end device for the neural model. Within the babbling phase the sensory-to-motor mappings and the spatial-to-joint coordinate mapping are learned using different sets of articulatory training patterns. Within the imitation phase the sound-to-sensory and the sound-to-motor mapping is learned basically by perceiving and reproducing sounds, syllables, and words.

Discussion

In order to establish powerful sensory maps within a quantitative computer implemented neural model of speech production, it is important to use a high quality front-end device, i.e. an articulatory speech synthesiser capable of generating realistic articulatory and acoustic signals. These signals serve as a basis for generating high quality somatosensory and auditive feedback signals. Furthermore it can be shown that a two level description of motor states is needed for an effective learning of sensory-to-motor mappings as well as for modeling sensorimotor phenomena like compensatory articulation or motor equivalence.

References

Birkholz, P. & Jackel, D. (2003). A three-dimensional model of the vocal tract for speech synthesis. *Proceedings of the 15th International Congress of Phonetic Sciences, Barcelona*, Spain, 2597-2600.

Guenther, F.H. & Perkell, J.S. (2004). A neural model of speech production and its application to studies of the role of auditory feedback in speech. In: B. Maassen, R. Kent, H. Peters, P. Van Lieshout, & W. Hulstijn (Eds.) Speech *Motor Control in Normal and Disordered Speech, 29-49*. Oxford: Oxford University Press.

THE ACQUISITION OF TWO PHONETIC CUES TO WORD BOUNDARIES

Melissa A. Redford[1], Christina E. Gildersleeve-Neumann[2]
[1]*Linguistics, University of Oregon,* [2]*Speech and Hearing Sciences, Portland State University, USA*
redford@uoregon.edu

Introduction

The study assessed whether acquisition of boundary-adjacent timing patterns is tied to syllable structure or whether these patterns are acquired separately as a means of highlighting word boundaries for the listener. If the patterns are tied to syllable structure, then they should emerge with the ability to produce different syllable shapes. However, if boundary-adjacent timing patterns are listener-oriented, then control over the patterns should emerge only after children have had extensive practice producing multi-word utterances. These two alternatives were explored in three experiments. The first assessed children's accuracy in produtions of different word onsets and offsets. The second focused on the production of phonetic word boundary cues. The third examined whether these cues were perceptually robust.

Methods and Results

Ten 3 ½ and ten 4 ½ year olds produced (1) real word stimuli with different syllable shapes (e.g., CVC and CCVC) and (2) real two-word stimuli with word-edge /s/+C sequences where word boundary location varied and C was a sonorant or stop consonant (e.g., *this nail* vs. *bitty snail* and *nice pot* vs. *my spot*). Analyses of all productions showed high syllable shape accuracy in children of both age groups, though 3 ½ year olds made more errors on clusters than 4 ½ year olds. Analysis of two-word productions showed that the durational cue to boundary location for /s/+sonorant sequences is absent at age 3 ½ and emergent at age 4 ½. In contrast, the allophonic cue to boundary location for /s/+stop sequences – presence vs. absence of stop aspiration – is acquired by age 3 ½. Perceptual judgments showed that the age-dependent acoustic differences translated into differences in listener behavior.

Discussion

The early acquisition of the allophonic cue to word boundary location suggests that this cue is tied to linguistic structure: the presence or absence of stop aspiration is an integral part of word production. In contrast, the late acquisition of the durational cue to word boundary location suggests that this cue is not tied to linguistic structure. Boundary-adjacent durational adjustments may instead be used to highlight boundary location for the listener. Thus, children may not control this type of cue until they have had extensive practice with multi-word utterances and are able to control different speech styles, an indication that they are able to modify their own productions to accommodate listeners. Overall, the study contributes to an understanding of the development of speech motor control. The results suggest that linguistic structure must be acquired before it can be manipulated for communicative effect.

References

Lehiste, I. (1970). *Suprasegmentals*. Cambridge, MA: MIT Press.

Turk, A. & Shattuck-Hufnagel, S. (2000). Word-boundary-related duration patterns in English. *Journal of Phonetics*, *28*, 397-435.

Goldstein, L. & Fowler, C.A. (2003). Articulatory Phonology: a phonology for public language use. In: A.S. Meyer & N.O. Schiller (Eds.) *Phonetics and phonology in language comprehension and production*, 159-207. Berlin: Mouton de Gruyter.

BODY PARTS IN INTERACTION WITH SPEECH EMERGENCE

Virginie Ducey-Kaufmann
Institut de la Communication Parlée, Grenoble, France
ducey@icp.inpg.fr

Short Overview

The general problem that children encounter in different areas of development is in the control of their body parts. The same situation is found for the *Speech Frame*, where the first rhythmically controlled supra-glottal segment is the mandible (MacNeilage, 1998), before "consonant" contacts and "vocalic" postures are controlled. Coordination and couplings recognized between systems, of the eye-head-hand type in dyadic and triadic interactions, should not make forget the interaction between oral-laryngeal control and cephalo-brachial control, in the complementary co-occurrence between gesture and speech.

Our working hypothesis is based on the idea that there is a "developmental rendez-vous" between what we call the "*Sign Frame*" and what we call the "*Speech Frame*". While the *Speech Frame* is established in the form of the canonical babbling around the age of 7 months, the *Sign Frame* appears first of all in the form of imperative pointing around the age of 9 months, before giving place to the so-called declarative pointing. Declarative pointing appears along with the first words, while the *Speech Frame* allows the child at that stage to coproduce (*coarticulate*) a vowel and a consonant. The relative importance of the elements of this developmental "rendez-vous" at the time of the emergence of the first words remains to be explored. In the present contribution, we would like to study the existence of a harmonic relationship between the *Speech Frame* and the *Sign Frame*.

To this end, we studied the distribution of the babbling frequencies, and of the durations of the pointing or "stroke" gestures. Our results for these six children, audio-visually recorded every fortnight during 12 months, show that with a babbling mode at 3 Hz and "strokes" gestures at 600-700 ms (1.5 Hz), we can account for the first words template. Thus, with these "prosodic words" that can vary from one to two syllables, it is necessary to call upon the *foot* as a metric control unit rooted in pointing. This will account for the current observations in the literature provided that instead of counting only syllables/words, one measures the mandible cycles control embedded in pointing "strokes".

References

MacNeilage P.F. (1998). The Frame/Content theory of evolution of speech production, *Behavioral and Brain Sciences*, *21*, 499-546.

Abry C., Ducey V., Vilain A., & Lalevée C. (in press). When the babble-syllable feeds the foot in a point, *Festschrift in Honour to Peter MacNeilage* (Barcelona ICPhS Satellite Conference 1-2 August 2003), London: Erlbaum.

Sussman H.M., Duder C., Dalston E., & Cacciatore A. (1999). An acoustic analysis of the development of CV coarticulation, *Journal of Speech, Language, and Hearing Research*, *42*, 1080-1096.

THE EMERGENCE OF DISCRETE GESTURES IN ITALIAN CHILDREN AGED 18-27 MONTHS

Claudio Zmarich[1], Michela Calegaro[1], Serena Bonifacio[2]
[1]ISTC -C.N.R., Padova, [2]IRCCS "Burlo-Garofolo", Trieste, Italy
zmarich@pd.istc.cnr.it

Introduction

In Articulatory Phonology the primitives of phonological structure are dynamically defined units of articulatory action, called "gestures", performing a constriction by means of one of the anatomically distinct effector systems within the vocal tract: lips; tongue blade, body and root; velum; glottis. Since these articulatory actions are categorically distinct per se, they may function as potential contrastive units in phonology. Other minimal phonological contrasts involve the same "organ" but are specified in terms of differences in constriction degree. According to Studdert-Kennedy and Goldstein (2003), speech error types made by 2-years-old children in their attempts to produce words contain many wrong segments, but few wrong gestures, because organ identification is developmentally prior to the ability to correctly imitate a specific act. Goldstein (2003) showed that errors in consonant place of articulation are much less frequent than voicing and manner errors.

Methods and Results

We investigated whether place errors are significantly fewer than manner errors, in 13 normally developing children learning Italian, tape-recorded at 18, 21, 24 and 27 months of age (Zmarich & Bonifacio, 2005). The first 50 different word types were selected for each child. Every CV(C) syllable initial consonants attempted by the child were selected for analysis if there was lack of correspondence to the target because of a sound substitution. The number of errors involving the oral constricting organ (lips, tongue tip, tongue body) or the constriction degree (stop, fricative, approximants) was calculated. The analysis of 429 errors shows that place errors are less frequent than manner errors, and there is a systematic increase in the number of correct matches for place features from the 18th to the 27th month.

Discussion

Apparently, the lower rates of place (*vs* manner) errors in children's productions confirm Goldstein's findings (2003), but the lower rate at 27 months than 18 months is against predictions. Moreover, when statistical significance was checked, by re-pairing randomly 100 times the infant errors and the adult targets (as a chance baseline), the number of errors in the 100 random matches that mantained the same manner features was always lower than the infants' errors-targets original matches. These results are in disagreement with Goldstein (2003), who found, for manner category, the unchanged random matches to overcome 99 times out of 100 the unchanged matches of the "original" errors-targets comparison. Some possible reasons for discrepancies are tentatively put forward.

References

Goldstein, L. (2003). The emergence of discrete gestures. *Proceedings of the 15th International Congress of Phonetic Sciences,* Barcelona, 85-88.

Studdert-Kennedy, M. & Goldstein, L. (2003). Launching language: The gestural origin of discrete infinity. In: M. Christiansen & S. Kirby (Eds.) *Language evolution: The states of the art*, Oxford: Oxford University Press.

Zmarich C. & Bonifacio S. (2005). Phonetic inventories in Italian children aged 18-27 months: A longitudinal study. *Proceedings of INTERSPEECH'2005,* Lisboa, 757-760.

UNDER WHICH CONDITIONS DOES THE ADDITION BIAS EMERGE?

Marianne Pouplier
University of Edinburgh, Scotland
pouplier@ling.ed.ac.uk

Introduction

Speech errors are known to exhibit an addition bias in that segments are added rather than deleted (e.g., *pot luck => plot*, not *lot*). Dell (1984) further showed that a shared final consonant can cause an interaction of the initial consonants. A principled connection between these two phenomena has been drawn in a gestural account of errors (Goldstein et al., 2004): Articulatory measures revealed a preponderance of errors in which both the target and intruding gesture are coproduced (e.g., a tongue tip and tongue dorsum gesture in the same pre-vocalic position in *top cop*, instead of one replacing the other). This gestural addition bias has been interpreted as an errorful coupling of gestures in a dynamically stable coordination mode (1:1, in-phase), triggered by the presence of a shared coda consonant. The current paper investigates whether shared gestural composition other than a shared coda or rhyme can trigger coproduction errors.

Methods and Results

Tongue movement was recorded for five subjects using ultrasound. Subjects repeated two-word phrases with alternating initial consonants in a coda condition (e.g., *top cop*) and a no-coda condition (e.g., *ta ka*). A third condition investigated complex frequency relations in codaless three-word phrases (e.g., *ta ka ta*). Results showed a decreased error rate for the no-coda condition compared to the coda condition and an intermediate error rate for the three-word phrase condition. While all conditions exhibited both substitution and coproduction errors, the strong dominance of coproduction over substitution errors as reported by Goldstein et al. (2004), could be confirmed for the coda condition only; the no-coda condition showed an equal number of coproduction and substitution errors. The three-word phrase condition showed a small tendency for an addition bias to emerge.

Discussion

All conditions elicited both errors in which the intended consonant was replaced by another one (substitutions) and coproduction errors. This supports the hypothesis that at least in repetition tasks, errors can be interpreted as errors of gestural coordination. Error rates changed as a function of the amount of shared gestural composition: More errors occurred in the coda condition compared to the no-coda condition. This is consistent with the notion that errors can arise through errorful coupling of gestures, since coupling effects are known to be cumulative. That an addition bias was only observed under the presence of a coda consonant suggests that not all complex frequency ratios are sufficient to lead to a preponderance of coproduction errors in which an extralinguistically stable state comes to dominate over lexically stable states. The more gestures are shared between words, the stronger the tendency to produce synchronize alternating gestures will become.

References

Dell, G. (1984). Representation of serial order in speech: Evidence from the repeated phoneme effect in speech errors. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *10(2)*, 222-233.

Goldstein, L., Pouplier, M., Chen, L., Saltzman, E., & Byrd D. (2004). Gestural action units slip in speech production errors. *Submitted Manuscript*.

STABILITY OF COORDINATION PATTERNS IN TONGUE CONTROL IN NORMAL AGING

Janice Waugh Bennett[2,3], Pascal van Lieshout[1,2], Catriona M. Steele[2,1]
[1]University of Toronto, Oral Dynamics Lab, [2]Toronto Rehabilitation Institute
[3]St. Joseph's Health Centre, Canada
Bennett.janice@torontorehab.on.ca

Introduction

The literature on normal aging describes several structural changes that occur in the orofacial mechanism, but objective research on the functional effects of these changes is limited (Caruso, Mueller et al., 1995). It is also unknown whether age-related changes are gender or task specific. Structural changes in tongue muscles could be expected to have different implications for swallowing and speech, as these functions serve different purposes. Previous research in our lab has shown greater variability in tongue motion in healthy older people (Steele & Van Lieshout, 2004). This investigation compares tongue and jaw gestures and their coordination in re-iterated speech and sequential swallowing tasks.

Methods and Results

Electromagnetic midsagittal articulography was used to measure mandible and tongue movement in 11 older (50 to 80 years; 5 male, 6 female), and 10 younger (18 to 30 years; 5 male, 5 female) participants. The tasks were trial sets with re-iterations of "ipa", "api", and "pataka", and 6 sequential water swallows. Individual movements were analyzed for distance, duration and variability (cSTI); the nature and stability of coordination patterns between mandible and three fleshpoints on the tongue were analyzed for relative phase and spectral coherence. Results showed that, in general, individual swallowing gestures were more variable, with longer movement durations, than individual gestures for speech. In terms of coordination, swallowing tasks showed greater variability and weaker coherence than speech tasks. These task differences for coordination were less pronounced for young males. No such effects were apparent for speech.

Discussion

The two principle findings were that swallowing movements were slower and more variable than speech movements, and that an age effect was found for males in swallowing. These differences may be interpreted in terms of task goals. Whereas tongue motion in swallowing must generate precise force control to propel the bolus effectively through the oral cavity, speech requires less force and more precision in speed and accuracy of the gestural coordination of the tongue. The slower durations for swallowing may suggest a stronger emphasis on feedback driven strategies to accommodate physical properties of the bolus, such as its mass. The age effect seen in young males is under further investigation.

References

Caruso, A.J., Mueller, P.B., & Shadden, B.B. (1995). Effects of aging on speech and voice. *Physical and Occupational Therapy in Geriatrics*, *13(1/2)*, 63-79.

Steele, C.M. & Van Lieshout, P. (2004). Influence of bolus consistency on lingual behaviours in sequential swallowing. *Dysphagia*, *19(3)*, 192-206.

EFFECTS OF VARYING SPEAKING RATES ON SPATIOTEMPORAL TONGUE-TIP MOVEMENT PATTERNS

Sungbok Lee[1,2], Shrikanth Narayanan[1,2], Dani Byrd[1]
[1]Dept. of Linguistics, [2]Dept. of Electrical Engineering,
University of Southern California, LA, USA
sungbokl@usc.edu

Introduction

A speaker can talk slower or faster than usual depending on his or her communication need or mode (c.f., Crystal & House, 1988). However, little attention has been given to the topic of how well a speaker has established timing controls for target speaking rates. This study investigates the question of the stability of self-regulated speaking rate and explores the kinematics of tongue tip gesture as a function of speaking rate and order. We asked a speaker to produce a set of sentences with three different speaking rates of normal, slow and fast. Specifically, the subject produced each target sentence three times *in a row* with a pre-specified order of combination of normal (*N*), medium (*M*), and fast (*F*) speaking rates (i.e., *N-M-F, F-M-N, N-F-M, F-N-M, M-N-F, and M-F-N*). The *order* of change in speaking rate is the independent variable of interest.

Method

Speech material is consisted of 20 Tamil sentences of "*Andha vakyam* [target-word] *perusu*" and each sentence produced three times in a row with the six pre-defined orders of combination of self-regulated speaking rates. Target words are not a factor in the current study. Data on speech acoustics, segmental durations, and tongue-tip kinematics were obtained using an Electromagnetic articulography system (Carstens Ag200). Durations were measured at two different time scales: a long interval (e.g., 6 sentence-medial syllables) and a short gestural interval (e.g., an /nd/-cluster closure and release). Kinematic parameters associated with tongue-tip movements were also derived from EMA data. These data were analyzed as a function of the order of speaking rate.

Results and Discussion

It is found that change in speaking order (e.g., speeding-up vs. slowing-down) significantly affects not only segmental duration but also voicing effort and articulatory kinematics. These contextual effects of the order of speaking rate suggest that the speaker recalibrates the self-regulated speaking rate, either linearly or non-linearly, depending on preceding and/or upcoming rate. For instance, in the case of N-F-M versus F-N-M, segmental duration of normal or medium speaking rate is deceased when the fast speaking rate follows and vice versa. Therefore, the timing control associated with speaking rate seems fairly variable depending the environment or context, which should be considered in any speaking rate experiment design and analysis with multiple speaking rates. It is also noted that speech motor control for timing becomes more compact or precise in terms of variability when speech is faster. This was not the case for spatial variations.

Reference

Crystal, T. & House, A. (1988). A note on the variability of timing control. *Journal of Speech and Hearing Research*, *31*, 497 502.

ACOUSTIC PARAMETERS OF PHARYNGEALIZED CONSONANTS

Tatian Ryzhikova, Irina Selyutina, Nikolay Urtegeshev
Institute of Philology of SB RAS, Novosibirsk, Russia
lefi@philology.nsc.ru

Introduction

On the territory of Southern Siberia there are more than 40 languages, dialects and sub-dialects. Many of them are without written tradition and poorly investigated. Laboratory of Experimental-Phonetic Researches (LEPR), IPh SB RAS has been carrying on a total experimental-phonetic investigation of these languages since 1968. At that time V. M. Nadyelyayev initiated a new study of minority languages and founded the Siberian Phonological School, which pursued the traditions of academician Scherba's Leningrad scientific school.

All studies are based on V. M. Nadelyayev's theory of acoustic-articulatory base (AAB) – a system of pronunciation habits with their acoustic effects that historically being worked out on the early stages of an ethnos formation. Having acquired a new language but having preserved its AAB the ethnos engenders a new dialect of the language with new sound system.

Methods and Results

To obtain objective material the phoneticians of LEPR apply both articulatory and acoustic methods. All phonetic material collected by the scientists mainly in the field from the bearers of the language and recorded sometimes in the laboratory in the presence of the dictors is computer processed. The obtained results are tabulated for further interpretation.

At this stage it is possible to say that in some Southern-Siberian Turkic languages there exist special pharyngealized consonats. Pharyngealization is characteristic mainly of vocal systems and phonologically functions in some world languages, but pharyngealization of consonants has been noted for the first time by N. S. Urtegeshev on the territory of Siberia in the Shor language. The investigation of the Baraba-Tartars' language has proved that this phenomenon is also true for this linguistic union and has special acoustic colouring.

Discussion

Firstly it was auditory noted that in Baraba-Tartars' there function some sounds that are perceived as «rude, rough» and extremely tense. In the course of experimetal research it has been stated to be so. Acoustic computer analysis of pharyngealized consonats proved that these sounds have longer duration and specific high-low resonance. In Shor static consonants are characterized by medium equal resonance; injective-ejective ones – by high rising resonance; ejective-injective ones (in common terms – pharyngealized consonants) – by low lowering resonance. In Tuvan pharyngealization is phonemic for vocal system organization but also actively functions in consonant system and is clearly distinguished auditory by the bearers of the language. Thus, we can say that pharyngealization in general is live and active phenomenon in Southern-Siberian Turkic languages and though it has specific articulation nevertheless it can be also noted auditory and computer analysis proves it.

References

Selyutina I.Ya., Urtegyeshev N.S., & Ryzhikova T.R. (in press). *Pharingalizatsiya v turkskikh yazykakh Yuzhnoi Sibiri kak otrazhenie yazykovykh kontaktov*. Moscow.

ACOUSTIC CORRELATES OF HYPERNASALITY IN CONSONANTS

Valter Ciocca[1], Danny P.-W.Chen[1], Alice S.-Y. Lee[2], and Tara L. Whitehill[1]
[1]*Division of Speech & Hearing Sciences, Hong Kong University, Hong Kong SAR, China*
[2]*Speech Science Research Centre, Queen Margaret University College, Edingburgh, UK*
vciocca@hkusua.hku.hk

Introduction

Hypernasality is a perceptual characteristic of speech produced by individuals with resonance disorders. Because of the poor reliability of perceptual judgements of hypernasality, researchers have attempted to develop more reliable estimates by using acoustic measurements. Traditionally, acoustic studies of hypernasality have focused on vowel production. Unfortunately, vowel-derived measures of hypernasality are time-consuming, highly dependent on talker characteristichs, and are affected by formant frequencies and phonetic contexts. The aim of this study was to obtain reliable spectral correlates of hypernasality by performing 1/3 octave band analysis on consonants obtained from samples of fluent speech produced by speakers with cleft palate and maxillectomy.

Methods and Results

The speech materials were two alveolar consonants (/s/ and /n/) produced by 14 adults with either cleft palate (12) or maxillectomy (2), and 20 control speakers. Samples of /n/ were produced within single Cantonese words (/man_{22}/ and /min_{22}/, each repeated five times). Samples of /s/ were obtained from five Cantonese words (/sei_{33}/, /sik_{2}/, /si_{21}/, /sik_{5}/, and /sy_{55}/) produced within oral sentences.

Energy levels within 1/3 octave bands were calculated using the procedure by Kataoka et al. (2001). Two metrics were calculated for each speaker: i) 'High5', representing the difference in level between /s/ and /n/ spectra at high frequencies, and ii) 'High-Mid3', representing the difference in energy level between high and mid frequency bands of /s/ spectra. Both measures were found to be significantly different between hypernasal and control groups, and to significantly correlate with perceptual ratings of hypernasality. These spectral measures also showed high intra- and inter-judge reliability.

Discussion

The metrics based on the analysis of /s/ and /n/ spectra were easy to calculate, highly reliable, and suitable for the analysis of fluent speech samples of speakers with cleft palate and maxillectomy. These spectral measurements were also found to be more highly correlated with perceptual judgments than both i) 1/3-octave-band measurements of vowels produced by, and ii) nasalance scores obtained from the same speakers. These results show that spectral measurements of fricative consonants obtained from connected speech samples could be useful for the clinical assessment of resonance disorders.

References

Kataoka, R., Warren, D.W., Zajac, D.J., Mayo, R., & Lutz, R.W. (2001). The relationship between spectral characteristics and perceived hypernasality in children. *Journal of the Acoustical Society of America*, *109*, 2181–2189.

Kent, R.D., Weismer, G., Kent, J.F., Vorperian, H.K., & Duffy, J.R. (1999). Acoustic studies of dysarthric speech: Methods, progress, and potential. *Journal of Communication Disorders*, *32*, 141–180.

LARYNGEAL REFLEX RESPONSES ARE MODULATED DURING VOICE PRODUCTION AND EFFORT CLOSURE

Victor M. Henriquez[1], Geralyn Schulz[1,2], Steven Bielamowicz[1,3], Christy L. Ludlow[1],
[1]Laryngeal & Speech Section, NINDS, Bethesda, MD, [2]Dept.of Speech and Hearing Science, GW University, DC, [3]Dept.of Otolaryngology, GW University Hospital, DC, USA
henriquez@ninds.nih.gov

Introduction

The laryngeal adductor response (LAR) is an airway protective reflex that prevents entry of substances into the lungs. Stimulation of the laryngeal mucosal afferents contained in the superior laryngeal nerve (SLN) will elicit this reflex in humans at rest. Because voicing requires accurate voluntary control of vocal fold length and tension changes during phonation, responses to sensory changes may be suppressed during this task. Previously, we demonstra-ted that during volitional swallow, the LAR is transiently suppressed (Barkmeier et al., 2000). In this study, we hypothesized that the LAR would be suppressed in humans during volitional laryngeal control for phonation and effortful closure in contrast with quiet respiration.

Methods and Results

Eleven normal subjects had normal laryngeal structure and function and were without any current or past history of speech, voice, neurologic, or psychiatric disorders. Similar to previous experiments, bipolar electromyography (EMG) needle electrodes to locate the laryngeal muscles using standard techniques before placing the bipolar hooked wires into thyroarytenoid (TA) muscles bilaterally. The baseline level of muscle activity before stimulation during a task and the amplitude of the R1 responses were measured during six sets of stimuli presented each during quiet inspiration, continuous vowel production and effort closure with 20 s between each stimulus presentation. The mean baseline activity was subtracted from the mean response amplitude before computing the integral of the response (mean x duration) in each condition. To test whether volitional tasks suppressed R1 LAR responses, we computed the difference in the R1 response integral between rest and each task condition (Rest – Task > 0).

Discussion

The changes in amplitude of the R1 during volitional tasks with the laryngeal adductor reflex are consistent with changes seen during voluntary swallow (Barkmeier et al., 2000). Suppression of the reflex was seen as tendency for suppression in both the probability of a response and the amplitude of both the R1 and R2 evoked responses during the different vocal tasks. This reduction was not due to baseline subtraction because baseline amplitudes were positively related to response integrals (r=+0.8-.95) during each task but not to condition suppression (r=0.4-0.5). The R1 response is an ipsilateral motoneuron response to sensory input believed to involve a direct brain stem pathway (Sessle, 1973). These findings suggest that during volitional tasks such as phonation there is a central gating of motoneuron responses to sensory inputs.

References

Barkmeier, J.M., et al. (2000). Modulation of laryngeal responses to superior laryngeal nerve stimulation by volitional swallowing in awake humans. *Journal of Neurophysiology*, *83(3)*, 1264-72.

Sessle, B.J. (1973). Excitatory and inhibitory inputs to single neurones in the solitary tract nucleus and adjacent reticular formation. *Brain Research*, *53(2)*, 319-31.

MODULATION OF AUDITORY PROCESSING DURING THE PLANNING OF SPEECH MOVEMENTS

Ludo Max
University of Connecticut, Storrs, Haskins Laboratories, New Haven, CT, USA
ludo.max@uconn.edu

Introduction

The underestimation of self-generated forces, the inability to tickle oneself, and reduced cortical responses to one's own speech suggest that the neural control of movements involves an attenuation of re-afferent inputs. However, the mechanisms underlying this attenuation remain unknown. For example, during some tasks, the central nervous system's (CNS) response to *external* inputs is also attenuated. Hence, the phenomenon is not fully explained by the proposal that the CNS detects a match between predicted and actual consequences. Moreover, the time course and role of such sensorimotor interactions remain unclear. The purpose of this work was to explore and refine a paradigm in which external auditory stimuli are delivered during a response delay interval prior to the onset of speech movements. Electrophysiological recordings were used to examine the central auditory pathway's response to predictable and unpredictable stimuli delivered during movement planning.

Methods

Two experiments were conducted, each with 8 neurologically healthy young adult subjects. Both experiments included 4 conditions during which recordings were made of long-latency auditory evoked potentials (LLAEPs) in response to 1 kHz tone bursts (75 dB SPL) presented binaurally. Condition 1 was a delayed-response *speaking task*. Subjects first read and then – after a *go* cue 600 ms later – produced monosyllabic words individually displayed on a computer monitor. Condition 2 consisted of a silent *reading task*, thus eliminating the effects of movement planning. Condition 3 consisted of a *seeing task* that eliminated the effects of reading. For each trial, a horizontal series "+" symbols, rather than a word, was presented. Condition 4 was a rest condition during which the subjects sat quietly with their eyes closed. For *Experiment 1*, a tone was delivered 300, 400, or 500 ms after initial presentation of each display in Conditions 1-3. For *Experiment 2*, the predictability of auditory stimulation was reduced by delivering a tone only during 1/3 of the trials in Conditions 1-3. LLAEPs were recorded in epochs from 100 ms before to 400 ms after tone onset.

Results and Discussion

Findings from Experiment 1 indicated that, depending on the timing of the tone burst, aspects of the EEG signal in the post-stimulus interval are highly similar for the rest, seeing, and reading tasks but different for the speaking task. Preliminary results from Experiment 2 suggest that the changes in the EEG signal prior to speech onset specifically reflect a modulation of afferent signal processing in the central auditory pathway rather than a general effect on various neural sources contributing to the recorded EEG signal (complete results will be presented at the meeting). These data will be discussed in the context of theoretical models of neural control that combine afferent signals, efference copy, and forward internal models for optimal state estimation (optimal feedback control).

Reference

Blakemore S.J., Wolpert D. & Frith C. (2000). Why can't you tickle yourself? *NeuroReport, 11,* 11-16

WORD FREQUENCY AND THE PHONOLOGIC SIMILARITY EFFECT: AN INVESTIGATION OF SPOKEN LANGUAGE PRODUCTION MECHANISMS

Margaret A. Rogers and JoAnn P. Silkes
Department of Speech and Hearing Sciences, University of Washington, Seattle, WA, USA
mrogers@u.washington.edu

Introduction

Previous research has begun to address the processes by which the phonological form of words is prepared for spoken language production. Using a form-based priming paradigm and measuring the Phonologic Similarity Effect (PSE), which occurs only if phonological features are being activated, Rogers and Storkel (1998) concluded that all words are actively assembled from sublexical components each time they are produced anew. Specifically, their Obligatory Assembly Hypothesis states that assembly occurs at the level of phonological features. Others have proposed that low frequency and novel words undergo sublexical assembly, but high frequency words bypass this mechanism by having their motor plan fully intact and retrieved with the lexeme (Whiteside & Varley, 1998). Within this Dual-Route Hypothesis, high frequency words are *thought to be* routed directly to the motor output system, with *no* phonological processing. The *present* study was undertaken to test these two competing hypotheses.

Methods and Results

25 participants completed a form-based priming task, quickly reading words presented in rapid sequence on a computer screen. Target words were either very high (100-1000 words per million) or very low (<10 words per million) frequency. Targets were preceded by rhyming low frequency prime words that shared either no phonological features with the initial phoneme of the target or shared voicing and manner of articulation with the initial phoneme of the target. Reaction times (RTs) from the onset of each word to the onset of voicing was measured and transformed to normalize for inter-target and inter-subject variability. The presence of the PSE was determined by comparing transformed RTs for words in the zero-shared condition with those for words in the voice/manner-shared condition. The PSE was evident for high frequency words. Low frequency words demonstrated an unexpected pattern of facilitation, rather than interference, for phonologically related words.

Discussion

The presence of the PSE for high frequency words is not consistent with the Dual-Route Hypothesis. The apparent reverse PSE for low frequency words was shown to be related to the persistence of the PSE into anticipated repetitions of target words, suggesting either that: 1) the composition of the motor program for spoken word production can vary depending on the context in which the word is assembled, or 2) that assembly of phonological word forms occurs even for anticipated repetitions.

References

Rogers, M. A. & Storkel, H. L. (1998). Reprogramming phonologically similar utterances: the role of phonetic features in pre-motor encoding. *Journal of Speech, Language and Hearing Research*, *41(2)*, 258-274.

Whiteside, S. P. & Varley, R. (1998). A reconceptualisation of apraxia of speech: A synthesis of evidence. *Cortex*, *34*, 221-231.

SERIAL-ORDER ACTIVATION OF SPEECH ARTICULATORS: NEURAL COMMANDS DO NOT OPERATE IN TERMS OF *SEGMENTS*

Victor J. Boucher
Université de Montréal, Canada
victor.boucher@umontreal.ca

Introduction

Prominent models of speech-motor control assume that neural commands to articulators follow the sequential order of phoneme segments. As an example, close-open cycles of the lips and jaw in *papapa…* are seen to be serially organized by reference to strings of features like [+cons] [-cons]. Thus, the models prescribe serial commands that activate adductors to close the lips and then abductors to part the lips.

EMG and kinematic data are presented showing that lip and jaw abductors are not active during release openings. Instead, they may represent spring-like behavior of relaxing muscles. In a spring system, the range and speed of mass displacement are proportional to the contracting force. Applying this analogy, measures of oral pressure and lip compression can be used to approximate contraction force. If release motions reflect muscle elasticity, then pressure and compression would be linearly related to the distance and speed of lip and jaw opening.

Methods and Results

The observations focus on the lip and jaw motions of three subjects who produced several series of *papapa…* and *bababa…* These series were uttered at increasing intensities so as to emphasize changes in compression and pressure. Kinematic and aerodynamic measures were accompanied by a monitoring of onsets of EMG activity for the main jaw and lip abductors and one lip adductor (*orbicularis oris* m.).

Again, onset of EMG activity accompanied closing and compression but not release openings. The main results show that oral pressure, especially, was a strong predictor of the distance and speed of lip and jaw opening ($.896 \geq R^2 \geq .402$, $p = .000$ overall).

Discussion

Current models assume that closing and releasing motions in articulators reflect serial activation in terms of postulated targets in a score (as in the *Task Dynamic* model (Perrier & Ostry, 1996)) or strings of equilibrium points specified by the CNS (as in the *Equilibrium-Point Hypothesis* (Saltzman & Munhall, 1989)). However, the serial ordering of these targets or points is conceived by reference to linguistic notions of segments, as seen in alphabetic-phonetic symbols. The above results indicate that such assumptions may not explain intrinsic factors of releasing movements in articulators. Moreover, close-open cycles in speech articulators are likely to originate from cycles of contraction and relaxation, and not from a priori segmental commands.

References

Perrier, P. & Ostry, D. (1996). The equilibrium point hypothesis and its application to speech motor control. *Journal of Speech and Hearing Research, 39,* 365-378.

Saltzman, E.L. & Munhall, K.G. (1989). A dynamical approach to gestural patterning on speech production. *Haskins Laboratories Status Report on Speech Research*, *SR-99/100*, 38-68.

A REAL-TIME ARTICULATORY-CONTROLLED VOWEL SYNTHESIZER FOR RESEARCH ON SPEECH MOTOR LEARNING

Jordan R. Green, Lien Phan, Ignatius Nip, and Antje Mefferd
Department of Special Ed. and Com. Disorders, University of Nebraska - Lincoln, USA
jgreen4@unl.edu

Introduction

When learning to speak, young children use auditory feedback to learn associations between articulatory movements and their acoustic consequences (Guenther et al., 1998). Presumably, this process involves the inverse mapping from acoustic goals to vocal tract shapes to muscular forces. Adults with acquired speech impairments may also undergo a similar inverse mapping process when regaining speech following injury to the vocal tract or the neural structures that govern speech. The principles underlying speech motor learning and re-learning are poorly understood though such knowledge is essential for treatments designed to improve speech. In this investigation, we examine the usefulness of a real-time articulatory-controlled vowel synthesizer for conducting experiments on auditory-motor associative learning in speech. Experiments were conducted to determine participants' ability to generate corner vowels using the synthesizer and to adapt to experimental manipulations of the mappings between mouth shape and vowel sounds.

Methods and Results

Three neurologically intact adult participants with normal hearing were studied. Lip movements were registered in 3D at 30 fps using an infrared motion capture system. Mouth shape was computed in near real-time and was used as a MIDI controller to trigger the playback of prerecorded vowel samples. In the first condition, speakers were instructed to use the synthesizer to generate corner vowels using an unaltered mouth shape-to-vowel map. In the second condition, the participants were required to adapt to large alterations in mapping between mouth shapes and vowel sounds. Articulatory accuracy, time-to-target, and path distance were measured across trials for the unaltered and altered map conditions. Preliminary data indicate that all of the participants were able to generate accurate vowel sounds on their first trial using the synthesizer during the unaltered map condition. In addition, two of the participants rapidly adapted to the experimental manipulations of mouth shape-to-sound relations.

Discussion

These preliminary findings suggest that the articulatory-controlled synthesizer is a useful tool for investigating auditory-motor associative learning. Participants were able to use auditory feedback provided by the synthesizer to form new mappings between articulatory targets and acoustic goals. This findings is consistent with prior studies demonstrating that healthy adult talkers rapidly adapt to perturbations of speech movements and speech/vocal feedback, and alterations of vocal tract anatomy (Houde & Jordan, 2002; Tremblay, Shiller, et al. 2002). Additional work is needed to determine if these preliminary findings generalize to a larger group of subjects.

References

Guenther, F. H. (1995). Speech sound acquisition, coarticulation, and rate effects in a neural network model of speech production. *Psychological Review*, *102*, 594-621.
Houde, J. F. & Jordan, M. I. (1998). Sensorimotor adaptation in speech production. *Science*, *279*, 1213-1216.

RESPIRATORY CONTROL: RESPONSES TO DYNAMIC MECHANICAL LOADING DURING VOCALIZATION IN CHILDREN

Donald S. Finan[1,2]; Carol Boliek[3]; Jennifer Maybee[1]
[1]*Speech, Language & Hearing Sciences,* [2]*Center for Neuroscience, University of Colorado, Boulder,* [3]*Speech Pathology and Audiology, University of Alberta, Edmonton AB, CA, USA*
Don.Finan@colorado.edu

Introduction

Like many other rhythmic movements, respiratory behaviors arise from a central pattern generator (CPG). Modulation of the respiratory CPG function is requisite to generate the air pressures and flows essential for speech production. The emergence of voluntary respiratory system control likely parallels and contributes to the development of speech. Perturbation experiments have proven to be fruitful in exploring neural control of many CPG-modulated behaviors. Little is known about the development of respiratory control, especially for complex behaviors such as speech production.

The purpose of this study was to investigate CPG-modulated and voluntary responses to respiratory perturbation in children. A new stimulation technique is described for mechanically perturbing the chest wall in behaving children.

Methods and Results

A series of controlled mechanical loads were delivered to the chest wall during rest breathing and sustained /a/ productions in 12 normally-developing children (mean age = 9.1 years). Stimuli were delivered via a circumferentially applied pneumatic bladder, actuated rapidly (*impulse*) or slowly (*sinusoid*), thereby modulating respiratory movements and resultant aerodynamics. Measured signals include speech acoustics, respiratory kinematics, and bladder pressure.

Impulse stimuli applied during the inhalation phase of rest breathing resulted in modulation of the subsequent cycle. Impulse stimuli presented during sustained /a/ production evoked increases in phonatory frequency, amplitude, and variability. Sinusoid stimuli applied during sustained vowel production evoked increases in phonatory variability and yielded significant correlations between phonatory variables and respiratory movements.

Discussion

The current experiment provides evidence that the respiratory system is responsive to mechanical stimuli applied to the chest wall. Impulse stimuli delivered during rest breathing resulted in changes in the subsequent respiratory cycle, suggesting transient modulation of respiratory CPG function. Impulse stimuli delivered during sustained /a/ production yielded brief increases in phonatory variability. It is not clear whether the phonatory changes were the result of central processes or of laryngeal aerodynamic/mechanical interactions. Correlations between respiratory and phonatory variables observed during sustained /a/ sinusoid stimuli suggest an inability to voluntarily compensate for this slow perturbation.

References

Calabrese, P., Dinh, T. P., Eberhard, A., Bachy, J-P., & Benchetrit, G. (1998). Effects of resistive loading on the pattern of breathing. *Respiration Physiology*, *113*, 167-179.

Oku, Y., Dick T. E., & Cherniack, N. S. (1993). Phase-dependent dynamic responses of respiratory motor activities following perturbation of the cycle in the cat. *J Physiology*, *461*, 321-327.

A PARAFAC MODELING OF LINGUAL ARTICULATION IN VOWEL PRODUCTION IN NINGBO CHINESE

Fang Hu
Phonetics Lab, Institute of Linguistics, Chinese Academy of Social Sciences, Beijing, China
fong.hwu@gmail.com

Introduction

Speech articulation is controlled by the speech motor system through muscular activities. Among the articulators, the tongue plays a crucial role in configuring the vocal tract shape, which further determines speech acoustics. Lingual articulation is of particular importance to understand both physiological and acoustic aspects of speech production. Past studies have shown that the PARAFAC analysis captures the underlying mechanisms for the observed lingual gestural variations during vowel production and the results are physiologically interpretable (Harshman et al., 1977; Hoole, 1999).

This paper presents a PARAFAC modeling of lingual articulation in vowel production in Ningbo Chinese, a variety of Wu Chinese.

Methods and Results

The lingual articulatory data of all the ten phonemic vowels [i y ʏ e ø ɛ a ɔ o u] that occur in (C)V syllables were acquired from seven speakers, five male and two female, using Carstens EMA (AG 200 system) with receiver coils mounted on the speakers' articulators in the midsagittal plane. In this study, the three sampled tongue points were extracted for each vowel at the vowel's target position using the velocity minima criterion (Löfqvist et al., 1993; Löfqvist, 1999). The measured positional tongue-point data were preprocessed in such a way that the final data subject to the PARAFAC algorithm consisted of displacements from the mean tongue configuration of each speaker.

Results show that a two-factor model best captures the tongue movement of vowel production, and the model explains about 90% of variance. The model successfully decomposes the complicated tongue shapes into two underlying lingual movement mechanisms, namely "retraction and back raising" and "front raising". The production of each Ningbo vowel is then interpreted as a combination of the two extracted lingual movement mechanisms. The loading effect of speakers reveals that different speakers employ different lingual articulation strategies during vowel production.

Discussion

The PARAFAC modeling of vowels is a speaker-independent generalization concerning the sampled tongue positions and the inferred lingual gestures. The results from Ningbo Chinese are consistent with those from English and other European languages. The fact that the extracted lingual movement mechanisms are comparable to the functional representation of tongue muscle forces from the EMG study (Maeda & Honda, 1994; Honda, 1996) suggests that the PARAFAC model of lingual articulation has physiological implications and reflexes speech motor organization for vowel articulation.

References

Harshman, R. A., Ladefoged, P., & Goldstein, L. (1977). Factor analysis of tongue shapes. *Journal of the Acoustical Society of America*, *62*, 693-707.

Hoole, P. (1999). On the lingual organization of the German vowel system. *Journal of the Acoustical Society of America*, *106*, 1020-1032.

FORMANT PATTERN PREDICTABILITY BASED ON LINGUAL KINEMATICS

Antje S. Mefferd, Jordan R. Green
University of Nebraska - Lincoln, USA
amefferd@unlserve.unl.edu

Introduction

Articulatory specificity and consistency are known to vary as a function of speaking rate and loudness. For example, relative to typical speech, slow speech is associated with larger articulatory excursions (overspecification), but inconsistent movement patterns. While findings for slow speaking rate are robust, findings for fast and loud speech are mixed (i.e. Tasko & McClean, 2004).

Studies have also reported predictable changes in vowel distinctiveness in response to rate and loudness manipulation (i.e., Tjaden & Wilding, 2004). However, investigations have rarely examined how these speaking tasks affect acoustic variability. Moreover, the strength of association between kinematic and acoustic changes across these speaking tasks has not been determined. The present study addressed two questions: 1. Do speaking rate and loudness manipulations elicit predictable changes in articulatory performance? and 2. Do changes in articulatory performance elicit predictable changes in vowel acoustics?

Methods and Results

Eight typical speakers produced the sentence "Tomorrow Mia may buy you toys again" in typical, fast, slow, and loud speech. The movements of tongue dorsum were captured using 3-D Electromagnetic Articulography during "ia" in "Mia." To determine articulatory specification, lingual displacement for "ia" was measured. Acoustic specification was determined by measuring the Euclidean distances between "i" and "a" in F1/F2 planar space. Movement trajectory consistency was represented as the average standard deviation taken across 20 windows of a scatter plot containing movement trajectories associated with five repetitions of the target diphthong. Formant trajectory consistency was derived similarly using an F1/F2 scatter plot. Preliminary analysis of four participants revealed that articulatory performance changes in response to these speaking tasks were speaker-specific. Articulatory specification and acoustic specification were moderately correlated for each subject. In contrast, movement consistency did not predict formant consistency. Generally, the movements varied more than the acoustics.

Discussion

From a clinical perspective, these preliminary results suggest that rate and loudness manipulations affect articulatory kinematics in a speaker-specific manner. Therefore, these task may yield individually different effects on speech intelligibility in individuals with motor speech impairments. The complex relations between speech acoustic and kinematic consistency are in agreement with predictions made by Quantal Theory (Stevens, 1989).

References

Tasko, S.M. & McClean, M.D. (2004). Variations in Articulatory Movement With Changes in Speech Tasks. *Journal of Speech, Language, and Hearing Research*, *47*, 85-100.

Tjaden, K. & Wilding, G.E. (2004). Rate and Loudness Manipulations in Dysarthria: Acoustic and Perceptual Findings. *Journal of Speech, Language and Hearing Research*, *47*, 766-783.

Stevens, K.N. (1989). On the quantal nature of speech. *Journal of Phonetics*, *17*, 3-45.

SURFACE ELECTROMYOGRAPHY AND COMFORT: THE INFLUENCE OF THE EQUIPMENT IN MUSCLE ACTIVITY DURING SPEECH

Claudia Regina Furquim de Andrade[1], Fernanda Chiarion Sassi[2]
[1]*Department of Physiotherapy, Speech-language and Hearing Science and Occupational Therapy,* [2]*School of Medicine, University of São Paulo, Brazil.*
clauan@usp.br

Introduction

A lot has been done, especially during the last two decades, in order to increase the knowledge about the effects of physiological/organic and/or neurological alterations on the functioning of the facial muscles which are directly related to speech and/or oral movements. The purpose of this research was to investigate comfort, rest, maximum and minimum tension of the perioral muscles during the production of the phoneme /p/, in fluent speakers of the Brazilian Portuguese language and to compare the results of three different forms of surface electromyography signal detection.

Methods and Results

Participants were ten adult females (mean age of 22:6 years). Muscle activity was captured using a surface electrode positioned in the middle portion of the inferior perioral area, 2mm below the free margin of the lip. Procedures for data gathering were the same for the three testing conditions (silver, "pressing button" and "clip" electrodes). Recordings of the electromyographic activity were made for: rest position, maximum and minimum tensions used for the production of the phoneme /p/. Participants were also requested to judge the electrodes according to comfort. The gathered data were quantified in RMS and expressed in microvolts. Statistical analysis demonstrated significant difference for the three electromyographic testing conditions and for comfort when comparing simultaneously the three types of electrodes.

Discussion

The weight and configuration of the electrode (disc or bar format) seem to be the main factors responsible for alterations in labial occlusion and consequent recruitment of more muscle fibers, raising electromyographic activity. This was observed in the responses obtained for the rest position and for the ratio minimum/maximum speech tension; both situations presented values higher than those usually found in the literature. Participants related comfort to electrode size, pointing that the bar format electrode (silver electrode) was too big and interfered in speech, although its area of contact was similar to the disc electrode. As demonstrated by this research and others, electrode variables seem to interfere in the electromyographic activity of the face, especially because the monitored muscles are very small and less dense.

References

Andrade, C.R.F de & Sassi, F.C. (2003). A study about electromyography: rest, maximum and minimum labial tension in fluent speakers. *Pró Fono*, *15(2),* 111-16.

De Luca, C.J. (1997). The use of surface electromyography in biomechanics. *Journal of Applied Biomechanics*, *13(2),* 135-163.

ACCURACY OF A CAMERA-BASED MOTION TRACKING SYSTEM FOR OROFACIAL SPEECH AND NONSPEECH MOVEMENTS

Yongqiang Feng[1], Ludo Max[1,2], Thomas Mealy[3]
[1]*Dept. Communication Sciences, University of Connecticut,* [2]*Haskins Laboratories, New Haven,* [3]*Dept. Mechanical Engineering, University of Connecticut, USA*
ludo.max@uconn.edu

Introduction

Numerous questions in normal and disordered motor control require accurate analyses of coordinated orofacial movements. However, the cost of electromagnetic, optoelectronic, and ultrasound motion tracking systems (Whalen et al., 2005) is prohibitive for many research laboratories and limits the potential applications in clinical management. For lip and jaw movements, modifications of existing video-based motion tracking systems could form a low-cost alternative provided that they offer high temporal resolution and sub-millimeter accuracy (Caruso et al., 1989).

Here, we describe the accuracy of 2D and 3D position and displacement data recorded with a system that combines consumer-grade digital cameras (one for 2D, two for 3D) capturing 60/120/240 images per second, reflective markers, commercially-available computer software, and a custom calibration device.

Methods and Results

A calibration cube was engineered with 32 markers at known locations. For each test, calibration was performed by capturing images of this cube, digitizing the markers' locations, and entering the markers' known coordinates. Tests were completed at 3 frame rates and with 2 marker sizes. For *static* tests, markers were attached to a micrometer fixed in a small cube with additional markers that allowed an offline correction for imperfect alignment. The markers were moved five 1.27 mm steps in each direction along each measurement axis. For *dynamic* tests, markers were attached to a robot performing cyclic 4Hz movements with an amplitude of ~5 mm along each measurement axis. The robot's position encoders (resolution 0.03 mm) simultaneously recorded these movements. For 2D data (3D data included at the meeting), the average absolute value of the difference between measured and actual positions was 0.16 mm across all static tests. The average absolute difference between displacements measured by the camera system and by the robot was 0.12 mm across all dynamic tests.

Discussion

For static data, accuracy was greatest at 120 Hz, whereas dynamic data showed only a small effect of frame rate. The effect of marker size (3 vs. 6 mm) was negligible. Findings demonstrate that with minimal adjustments (a custom calibration cube) a camera-based motion tracking system can operate with sub-millimeter accuracy at frame rates that are well suited for kinematic analyses of lip/jaw movements for research and clinical purposes.

References

Caruso, A.J., Stanhope, S.J., & McGuire, D.A. (1989). A new technique for acquiring three-dimensional orofacial nonspeech movements. *Dysphagia*, *4*, 127-132.

Whalen, D.H., Iskarous, K, Tiede, M.K., Ostry, D.J., Lehnert-LeHouiller, Vatikiotis-Bateson, E., & Hailey, D. (2005). The Haskins optically corrected ultrasound system (HOCUS). *J. Speech Lang Hear Res*, *48*, 543-553.

STATIC AND DYNAMIC 3D ULTRASOUND IMAGING OF THE TONGUE FOLLOWING PARTIAL GLOSSECTOMY SURGERY: ASSESSMENT OF GROOVING AND SYMMETRY

Tim Bressmann[1], Heather Flowers[1], Elizabeth Ackloo[1], Chiang-Le Heng[1], Willy Wong[2] Jonathan C. Irish[3]
[1]*Department of Speech-Language Pathology, University of Toronto, Canada.*
[2]*Department of Computer Engineering, University of Toronto, Canada.*
[3]*Princess Margaret Hospital, University Health Network, Toronto, Canada*
tim.bressmann@utoronto.ca

Introduction

The speech outcomes following partial tongue resection and reconstruction are often highly variable. Our understanding of the impact of a partial tongue resection and reconstruction on the 3D shape of the tongue in speech is limited. The presentation summarizes the results from two studies that aimed to develop meaningful quantitative indicators for lingual movement and deformation in normal speakers and patients undergoing partial glossectomy surgery, based on static and dynamic 3D ultrasound imaging. In the first study, we evaluated the 3D tongue shapes during sustained speech sounds in order to describe the biomechanical properties of partially resected tongues. In the second study, we used the multiplanar paced sonography technique to reconstruct dynamic 3D tongue movement.

Methods and Results

In the first study, 3D ultrasound was used to acquire the tongue volumes of 9 sustained speech sounds in 12 normal speakers and 12 glossectomees. We calculated measures related to tongue protrusion, midsagittal grooving, and symmetry. The patients' postoperative concavity values were significantly lower than their preoperative values and than those of the normal controls. The ability to groove the tongue was significantly correlated to listener ratings of speech acceptability. In the second study, 6 controls and 1 glossectomee recited a metronome-paced poem. The movement of the tongue surface at four coronal planes was quantified, and a moving 3D surface was rendered. Movement velocities in different regions of the tongue were plotted as speed maps. It was found that the midline of the tongue moved faster than the lateral margins. In the partial glossectomee, the movement speed was higher on the operated than on the unaffected side.

Discussion

3D ultrasound imaging offers new insights into the biomechanical properties of normal and partial glossectomees' tongues. The research allowed us to identify important commonalities across a group of normal speakers and patients. The first study demonstrated how a lateral resection can affect the tongue's ability to form a midline groove and to move symmetrically. These findings have implications for the surgical reconstruction strategies. In the second study, plausible reconstructions of 3D tongue movement were achieved using the multiplaner paced sonography method, and preliminary functional indicators of tongue surface movement were identified. In future research, we will refine this method to investigate 3D tongue movement in speakers with structurally-related and neurological speech disorders.

References

Bressmann, T., Heng, C.-L., Irish, J.C. (2005). *Journal of Speech-Language Pathology and Audiology, 29*, 158-168.
Bressmann, T., Uy, C., Irish, J.C. (2005). *Clinical Linguistics and Phonetics, 19,* 35-52.

A NOVEL TECHNIQUE FOR TRIGGERING MECHANICAL PERTURBATIONS BASED ON FORMANT TRAJECTORIES

Takayuki Ito[1], Mark Tiede[1,2], David J. Ostry[3,1]
[1]Haskins Laboratories, New Haven, [2]Research Laboratory of Electronics, MIT, Cambridge, USA, [3]McGill University, Montreal, Canada
taka@haskins.yale.edu

Introduction

This work extends our earlier studies in which we observed compensation in formant trajectories in response to unexpected jaw perturbations that were delivered during utterances of the general form /siyCVd/, as in "see red." In previous work (Tiede et al. 2004) perturbations were triggered when jaw opening (for CV) exceeded a threshold relative to clench position. However, a potential drawback of this approach is that subjects can react to perturbation with increased jaw stiffness and decreased range of motion, thus modifying the phasing of perturbation with respect to the target vowel. In the work reported here perturbations are instead triggered based on real-time evaluation of the acoustic signal.

Methods and Results

Custom-made dental prostheses are used to help immobilize the head (upper jaw) and to couple a computer-controlled robotic device to the lower jaw. A 3 N perturbation force is applied to the jaw during one of every five repetitions, selected at random, with half of the perturbations applied downward and half upward. Audio (at 16 kHz) and jaw position (at 1 kHz) are recorded concurrently. An iterative form of the Burg algorithm is used to compute a continuously updated spectral estimate, from which formants are derived with one ms resolution over voiced vowel segments. Jaw perturbation is triggered when first formant values exceed a subject-normalized threshold; e.g., 30% of the /iy/ : /ae/ range for perturbing mid and low vowels, as in "see bed" or "see dab." This avoids the perturbation phasing problem associated with triggering on the basis of jaw position, because appropriate formant trajectories are produced by subjects whether achieved through the normal range of jaw movement or through an increased range of tongue motion when compensating for jaw stiffness, thus providing consistently phased triggering landmarks. In addition this acoustic-based approach has the advantage of supporting more natural carrier contexts for stimulus elicitation, in that perturbations may also be triggered potentially on specific vowel targets.

Discussion

The capacity to respond to unexpected environmental events is a hallmark of adaptability in motor systems. We have developed a new technique that permits us to explore this capability during speech production. Our procedure lets us deliver mechanical perturbations to the jaw at various phases of an utterance and to have the perturbations initiated on the basis of acoustical events, rather than the position of the vocal tract articulators.

References

Tiede, M., Guenther, F., Perkell, J., Zandipour, M., Houle, G., & Ostry, D., (2004). Perturbation and compensation in speech acoustics using a jaw-coupled robot, *Journal of the Acoustical Society of America*, *116*, 2631.

MANDIBULAR MOVEMENTS IN SPEECH: ELECTROGNATHOGRAPHY IN TEMPOROMANDIBULAR DISORDERS AND ASYMPTOMATIC INDIVIDUALS

Esther Mandelbaum Gonçalves Bianchini[1], Claudia Regina Furquim de Andrade[2]
[1] *School of Medicine,* [2]*Department of Physiotherapy, Speech-language and Hearing Science and Occupational Therapy, University of São Paulo, Brazil.*
esther.bianchini@uol.com.br

Introduction

The mandibular movements used in speech modify the spaces to allow different articulatory postures. Temporomandibular disorders (TMD) can cause general modifications in these movements due to the muscular and joint conditions. Electrognathography allows delineating and recording the mandibular movements, determining their range. The goal of this study was to verify the amplitude and characterization of the mandibular movements during speech, using electrognathography in individuals with TMD and in asymptomatic ones, analyzing possible interferences of these dysfunctions according to the following issues: vertical, anteroposterior and lateral range of movements.

Methods and Results

135 adult subjects, with no absence of teeth; with no dental occlusion alterations or maxillomandibular disproportion and with no dental prosthesis were divided in two groups: GI with 90 participants with TMD; GII with 45 asymptomatic participants. The mandibular movements were observed during sequential naming of pictures, while registrations were obtained with computerized electrognathography (BioENG – BioPak system), assessing the course of the mandibular movements, through the signals of a magnet. The mean values of amplitude were described for the two groups:

	Mandibular movements amplitude (mm)	**Opening: frontal plan**	**Protrusion**	**Retrusion**	**Translation to the right**	**Translation to the left**
GI	Mean	8,18*	2,20	4,77*	2,15	2,14
	Standard Dev.	2,37	0,96	1,76	1,14	1,04
GII	Mean	11,18*	1,98	5,66*	1,83	2,05
	Standard Dev.	2,79	0,82	2,08	0,74	0,88

* Statistically significant

Discussion

This study describes the three dimensional thresholds of mandibular movements in speech for Brazilian Portuguese, for the two groups of investigated individuals. Mandibular movements in speech were identified as being discreet, with an anteroposterior component and deviations in laterality. The presence of TMD shows reduction of the maximum mandibular opening and retrusion ranges and prevalence of unilateral deviations of mandibular movements during speech, pointing out its interference.

References

Nielsen, I.L., Marcel, T., Chun, D., & Miller, A.J. (1990). Patterns of mandibular movements in subjects with craniomandibular disorders. *Journal of Prosthetic Dentistry*, *63(2)*, 202-17.

Burnett, C.A. & Clifford, T.J. (1999). The mandibular speech envelope in subjects with and without incisal tooth wear. *International Journal of Prosthodontic*, *12(6)*, 514-8.

STUDYING COARTICULATION RESISTANCE WITH ULTRASOUND

Natalia Zharkova, Nigel Hewlett
Queen Margaret University College, Edinburgh, Scotland
nzharkova@qmuc.ac.uk

Introduction

Previous work in the context of the Degree of Articulatory Constraint (DAC) Model (e.g. Recasens et al. 1997) has relied on either EPG, EMA or acoustic data. Ultrasound displays an image of the midsagittal outline of the tongue surface (see Hewlett & Beck 2006 for an overview of the ultrasound scanning procedure). The purpose of this work is to use ultrasound to study coarticulation resistance in symmetrical V#CV sequences, to test some of the DAC model claims, and to hopefully add new information towards a more accurate formulation of articulatory constraints. The hypotheses are: 1) there will be a V-on-C effect; 2) there will be a C-on-V effect; 3) V-on-C effect will be greater than C-on-V effect; 4) /k/-on-/a/ effect will be greater than /t/-on-/a/ effect; 5) V2-on-C effect will be greater than V1-on-C the effect.

Methods and Results

Data from three speakers of British English were collected using the QMUC ultrasound system. The data were the sequences /a#ta/, /i#ti/, and /a#ka/, occurring in meaningful sentences (e.g. /aka/: "After that Ma cast an angry look at Leigh"), repeated fifteen times. Analysis consisted in identifying three time points in the acoustic signal: mid-V1, mid-C, and mid-V2, and in capturing three curves corresponding to the tongue contour. The xy data for each curve were compared by computing average distances between pairs of curves.
Comparison of tongue curves for /t/ in the context of /i/ vs /a/ demonstrated a significant V-on-C effect. Comparison of tongue curves for /a/ in the context of /k/ and /t/ demonstrated a significant C-on-V effect. The V-on-C effect was found to be much stronger than the C-on-V effect. In two subjects the /k/-on-/a/ effect was shown to be greater than the /t/-on-/a/ effect. The V2-on-C effect was greater than the V1-on-C the effect.

Discussion

The potential of ultrasound for measuring coarticulation resistance of speech sounds has been demonstrated. Measures of V-on-C and C-on-V effect have been designed. The comparative strength of V-on-C and C-on-V effects found in the study is explained by the different requirements on the tongue body posture for producing consonants and vowels, and is discussed in relation to major theories and models of coarticulation and motor control. V2-on-C effect being greater than V1-on-C effect is taken as evidence of a syllable boundary influence. Inter-subject variation in the comparative strength of /k/-on-/a/ and /t/-on-/a/ effect, as well as some more data showing cross-subject variability, is discussed as a possible factor contributing to the surface realization of the speech sounds' DAC values, other factors being the syllable structure and the multitude of temporal and spatial segmental interactions.

References

Hewlett, N. & Beck, J. (2006). *An Introduction to the Science of Phonetics*. Mahwah, NJ; London: Lawrence Erlbaum Associates.

Recasens, D., Pallares, M. D., & Fontdevila, J. (1997). A model of lingual coarticulation based on articulatory constraints. *Journal of the Acoustical Society of America*, *102*, 544-561.

RECENT ADVANCES IN THE PHYSIOLOGICAL ASSESSMENT OF ARTICULATION: INTRODUCING 3-DIMENSIONAL TECHNOLOGY

Bruce Murdoch
School of Health and Rehabilitation Sciences, University of Queensland, Australia
b.murdoch@uq.edu.au

Introduction

Recent years have seen the development and introduction of a range of new physiological instruments for investigating various aspects of articulatory function. Included among these techniques are electromagnetic articulography (EMA), electropalatography (EPG) and pressure sensing EPG. The aim of this paper is to describe and evaluate these techniques, highlighting their relative advantages, disadvantages and specific applications in assessing articulation in normal and disordered speakers.

Methods and Results

Emphasis will be given to those instruments that enable researchers and clinicians to examine articulatory functions in 3-dimensions, such as 3-D EPG and 3-D EMA (AG500). In addition the development and application of pressure sensing EPG will also be outlined. Each of these physiological techniques will be fully described in terms of their component hardware and underlying principles of operation. Problems encountered in the development and application of each instrument will be highlighted, including difficulties with calibration, accuracy of data, transducer limitations etc. The use of each technique in the assessment of normal and disordered speech will be illustrated wherever possible by reference to specific case examples, including cases drawn from various neuropathological groups. Research findings reported to date based on each of the above physiological instruments will be reviewed and the results summarised.

Discussion

The discussion will focus on the future development and application of 3-D technologies with particular emphasis given to their potential use in the rehabilitation of motor speech disorders by way of 3-D physiological biofeedback.

References

Murdoch, B.E., Goozèe, J.V., Veidt, M., Scott, D.H., & Meyers, I.A. (2004). Introducing the pressure sensing palatograph: The next frontier in electropalatography. *Journal of Clinical Linguistics and Phonetics*, *18 (6-8)*, 433-445.

FIVE-DIMENSIONAL ARTICULOGRAPHY

Phil Hoole, Andreas Zierdt
Phonetics Institute, Munich University, Germany
hoole@phonetik.uni-muenchen.de

Short Overview

In this contribution we will review current developments in the use of 5D electromagnetic articulography. The principle of operation will be briefly recapped in order to emphasize the fact that five dimensions represents the key feature both in terms of advantages as well as drawbacks with respect to the traditional two-dimensional EMMA systems.

The obvious advantages are the higher density of information per sensor, i.e 3 Cartesian coordinates (for position) and 2 spherical coordinates (for sensor orientation), and, related to this, the fact that the head of the subject no longer has to be physically constrained by a helmet. The drawbacks are equally related to the fact that one is working in a much higher dimensional space: position calculation (and, relatedly, calibration) involves solving a non-linear optimization problem. This makes position-calculation computationally very intensive, and in some cases unstable solutions are encountered, resulting in mistrackings.

Both the positive and more problematic aspects will be exemplified and discussed, drawing on recent recordings of various languages (including English, Mandarin, German, Moroccan Arabic) using a variety of experimental paradigms.

On the positive side, we will illustrate how a more complete picture of tongue configuration can be obtained. Monitoring of head movement will also be discussed. This is crucial for accurate recovery of articulator movements themselves, but is also interesting in its own right as part of the motor activity related to speech. In addition to improving the naturalness of the speaking situation, the freedom of head movement leads to a simple but major advantage: subjects can be expected to tolerate much longer recording sessions. Finally, 'difficult' articulators such as the velum should now be easier to capture reliably.

With regard to current drawbacks (and ways around them) we will illustrate the instabilities in position calculation that can occur. It appears that some regions of the five-dimensional search space do not provide robust minima as solutions to the optimization problem. In such regions, inevitable inaccuracies or distortions in the measured signals can lead to clearly aberrant calculated positions. We will illustrate how a first estimate of the measured positions can be used as a starting point for a more robust estimate, taking the continuity of speech movements into account, and show how the reliability of the final solution can be assessed. One particular area where the 5D system is at a disadvantage compared to 2D systems is that no real-time display of calculated positions is possible, thus making it more tricky to detect detached or malfunctioning sensors. A true real-time display remains a non-trivial task, but we will illustrate a potential approach to giving the investigator feedback with reasonably short latencies as to the estimated quality of the recorded data.

In short, while work remains to be done to ensure the same degree of accuracy over the whole 5D measurement space, the system already offers unparalleled scope for large-scale acquisition of flesh-point data.

References

Hoole, P., Zierdt, A., & Geng, C. (2003). Beyond 2D in articulatory data acquisition and analysis, *Proc. 15th ICPhS*, Barcelona, 265-268.

ARTICULATORY MEASUREMENTS IN CHILDREN WITH SPEECH PRODUCTION DISORDERS

Lian Nijland[1,2], Ben Maassen[1,2,3]
[1]Department of Medical Psychology / [2]ENT / [3]Peadiatric Neurology, Radboud University Nijmegen Medical Centre, The Netherlands

Introduction

Children with developmental apraxia of speech (DAS) are known for their unintelligible speech due to a high number of sound substitutions. Research on acoustic measures of DAS speech revealed valuable information about deficits in speech planning and programming, i.e. it suggests that these children produce incorrect realizations of correctly selected phonemes (Nijland, 2003). More subtle measurements might provide additional insight into the various stages of speech processing. Articulation disorders could originate from deficits at different levels of organization, such as the syllabic and phonological level, within syllabic gestural level, or motor planning, programming, or execution level. By using an *E*lectro*m*agnetic *M*idsagittal *A*rticulography (EMMA)-system direct measures of articulatory movements can be obtained. This provides a useful tool for distinguishing involvement of different levels in children with DAS, as will be argued in this presentation.

Method

In this presentation, kinematic data will be presented of 10 children (5;11 to 8;9 years old) with speech disorder DAS or phonological disorder (PD), and 6 children (6;4 to 9;8 years old) with typical speech development (see also presentation of Van den Berg et al. at this conference). Kinematic data were collected using the Carstens EMMA-system. Receiver coils were attached to the tongue tip, tongue body, lower jaw and upper lip and lower lip, with reference sensors on upper jaw and nose. A series of speech tasks was administered eliciting utterances that are contrastive at different levels of organization. Furthermore, various analyses were conducted to study articulatory interaction, such as coarticulation using displacement and coordination using relative phase-values.

Results and Discussion

At the conference differences in articulation between the children with speech disorders and the typically developing children will be presented with regard to the following levels of organization:

Foot and syllabic structure: repetitions of syllables with identical sound sequences but with contrastive syllable structures (C1C2V or C2VC1, as in /spa:/ and /pa:s/), or with contrastive prosodic structures (accent on first or second syllable /*PA*ta/ or /pa*TA*/).

Segmental or gestural level: coarticulation in syllable repetitions with different vowels (/ta/-/ti/-/tu/), coordination in repetitions of bi- and trisyllabic utterances (/pata/, /taka/, /pataka/) compared with monosyllabic utterances (/papa/, /tata/, or /kaka/).

Motor programming: motor equivalence studied in monosyllabic utterances produced with a bite-block clenched between the teeth.

Children with speech output disorders differed at several levels of speech organization.

References

Nijland, L., Maassen, B., Hulstijn, W., & Peters, H.F.M. (2004). Speech motor coordination in Dutch-speaking children with DAS studied with EMMA. *Journal of Multilingual Communication Disorders, 2(1)*, 50-60.

CLASSIFICATION IN MOTOR SPEECH DISORDERS: WHAT ARE THE ISSUES?

Gary Weismer
Waisman Center and Dept. Communicative Disorders,
University of Wisconsin-Madison, USA
gweismer@wisc.edu

Short Overview

This presentation will review the history of classification of motor speech disorders (specifically of dysarthria) and will discuss issues that are relevant to a theoretically-useful taxonomy of this type. The relationship between clinical and research uses of such a taxonony will be discussed. At the heart of the presentation will be the status of oromotor, nonspeech behavior and 'quasi-speech' tasks (e.g., syllable alternating motion rates, sustained vowels) vs. speech data in constructing the taxonomy. It will be argued that the dominant taxonomy – that resulting from the seminal work of Darley, Aronson, and Brown at the Mayo Clinic – has created certain obstacles to understanding motor speech disorders. For example, that taxonomy emphasizes the differences between different 'types' of dysarthria, and has therefore deflected attention from similarities between them. New speech data will be presented that suggest there is more that is common across the classically-defined, different forms of dysarthria, than has previously been reported. In addition, some data will be presented that show how speech tasks may be used to infer the integrity of speech motor control, and an argument will be made that oromotor, nonverbal tasks have little value in gaining insight to speech production capabilities.

References

Duffy, J.R. (2005). *Motor speech disorders (2nd ed.)*. St. Louis, MO: Mosby.

Weismer, G. (in press). Philosophy of research in motor speech disorders. *Clinical Linguistics and Phonetics*, *20*.

THE CLINICALL RELEVANCE OF TREMOR-DOMINANT AND AKINETIC-RIGID DOMINANT SUBTYPES OF PARKINSON'S DISEASE

Christopher R. Watts, Cynthia R. O'Donoghue, Jeffrey A. Marler
James Madion University, Harrisonburg, Virginia, USA
wattscr@jmu.edu

Introduction

Clinical subtypes of Parkinson's disease (PD) were first discussed in the 1980's and further delineated by Jankovic early in the last decade. Two specific subtypes, tremor dominant (TD) and akinetic-rigid dominant (ARD) have received the most attention. Differences between these subtypes on motor task performance, such as hand tapping rhythm, and other functional tasks have been reported. The purpose of this pilot study was to investigate whether the TD and ARD subtypes exhibit differential performance realted to motor speech abilities, and suggest how potential differences relate to clinical relevance for speech-language pathologists.

Methods and Results

Participants with idipathic PD were assigned to subtypes utilizing a motor phenotype score derived from the Unified Parkinson's Disease Rating Scale. Measures of motor speech peformance were collected, including: diadochokinetic (DDK) rate, coefficient of DDK period, F2 transition magnitude, F2 transition rate, physiological frequency range, and speech rate. The data suggested a trend in differential peformance between the two subgroups on selected experimental variables. Specifically, the TD group was faster and exhibited greater periodicity of alternating movements during the DDK task. F2 transitions, as measured from repeated /i-u/ productions, were smaller for the TD group and they took more time to reach the articulatory end point, compared to the ARD group. Measures of maximum physiological frequency range and speech rate during a connected speech task were not different.

Discussion

In the sample of participants studied for this investigation, the TD group appeared more accurate at movements requiring labial speed and regularity. In tasks requiring lingual movements, the TD group manifested a smaller range of movement in the articulatory space, and exhibited slower movements. However, the performance of the TD group more closely approximated that of normal adults.The preliminary data shows a trend which points towards a greater disability in articulatory function on maximum performance tasks experienced by the ARD group compared to the TD group. The results of this study to date should be interpreted with extereme caution due to the low sample size and lack of statisical comparison. However, they do warrant continued and expanded investigation on this topic.

References

Zetusky, W., Jankovic, J., & Pirozzolo, F.(1985). The heterogeneity of Parkinson's disease: Clinical and prognostic implications. *Neurology*, *35*, 522-526.

Yahalom, G., Simon, E., Thorne, R., & Giladi, N.(2004). Hand rhythmic tapping and timing in Parkinson's disease. *Parkinsonism and Related Disorders*, *10*, 143-148.

Jankovic, J., et al. (1990) Variable expression of Parkinson's disease: A base-line analysis of the DATATOP cohort. *Neurology*, *40*,1529-1534.

DIFFERENTIAL EFFECTS OF SUBTHALAMIC NUCLEUS DEEP BRAIN STIMULATION PARAMETERS ON SPEECH PRODUCTION IN PARKINSON'S DISEASE

Elina Tripoliti, Patricia Limousin, Ludvic Zinzro, SteveTisch,
Ellie Borrell, MarwanHariz
Unit of Functional Neurosurgery, Institute of Neurology, London, United Kingdom
e.tripoliti@ion.ucl.ac.uk

Introduction

Hypokinetic dysarthria occurs in the majority Parkinson's disease (PD) patients at some stage of the disease process (Logemann et al, 1978). Bilateral Subthalamic Nucleus Deep Brain Stimulation (STN-DBS) is particularly effective in improving limb movements (Limousin et al, 1998). However, dysarthria is less responsive to STN-DBS, with a variable response ranging from improvement of motor aspects of speech to deterioration of speech intelligibility. Both site and amplitude of stimulation have been implicated clinically as factors influencing speech response. The aim of this study is to appraise the role of both the site and amplitude of stimulation on speech production.

Methods and Results

This is an acute, double blind within-subjects design study. The site of stimulation is defined based on the post-operative stereotactic MRI data. Patients are assessed 6-12 months post bilateral STN-DBS, off medication and stimulated under six conditions, in a random order: inside the nucleus at low voltage; inside the nucleus at high voltage; above the nucleus at low voltage; above the nucleus at high voltage; at their clinical-ordinary parameters and off stimulation. The assessment comprises a speech recording of sustained phonation, a read passage, the Sentence Intelligibility Test (SIT) and a one minute monologue using the Computerised Speech Lab (Kay Elemetrics, 4150); Movement is assessed using the Unified Parkinson's Disease Rating Scale–III (UPDRS-III). Patients are also videotaped. The acoustical analysis compares spectral means and standard deviations of the Long Term Average spectrums for both sustained phonation and sentences. Perceptual data from the SIT and the UPDRS-III are compared.

Discussion

Preliminary findings from the first four patients show that speech intelligibility decreases by 35% on average when patients are stimulated out of the nucleus at high voltage compared to that inside the nucleus at high voltage. They suggest that intelligibility may respond more favourably to stimulation by the contacts inside the STN.

Speech response to stimulation warrants further investigations in order to maximise the clinical benefit from the surgical treatment and to explore the role of the STN in speech production and limb movement. Results from eight patients will be presented.

References

Logemann J.A., Fisher H.B., Boshes B., & Blonsky E.R. (1978). Frequency and co-occurrence of vocal tract dysfunctions in the speech of a large sample of Parkinson patients. *Journal of Speech and Hearing Disorders*, *43(1)*, 47-57.

Limousin P., Krack P., Pollak P., Benazzouz A., Ardouin C., Hoffmann D., & Benabid A.L. (1998). Electrical stimulation of the subthalamic nucleus in advanced Parkinson's disease. *New England Journal of Medicine*, *339*, 1105-1111.

LARYNGEAL-ARTICULATORY COUPLING IN THREE SPEECH DISORDERS

Christopher Dromey[1], Shawn Nissen[1], Nelson Roy[2]
[1]Brigham Young University, Provo, UT, [2]The University of Utah, USA
dromey@byu.edu

Introduction

This presentation focuses on data from three speech disorders to illustrate articulatory changes that arise when the larynx alone is the target of treatment. Articulatory acoustic or kinematic data were collected to determine whether improving phonation would impact articulator movement. The finding of treatment effects spreading beyond the target of the larynx has important implications for our understanding of disordered speech motor control.

Methods and Results

Lip kinematics in 7 speakers with spasmodic dysphonia (SD) were recorded before and after Botox injection of the vocal folds. Bilabial coordination indexes were more aberrant when spasm severity was greatest, moving toward control speaker values after voice treatment.

Pre/post treatment recordings from 111 women with muscle tension dysphonia (MTD) were analyzed for evidence of articulatory changes. Although treatment focused on the larynx, increases in vowel space and diphthong formant transitions suggest that increased articulatory dynamics accompanied the voice improvements. Control speakers showed no changes.

Lip kinematic data from 10 speakers with Parkinson disease (PD) revealed increased amplitudes and velocities, along with more consistent trajectories over multiple repetitions for loud speech. Acoustic recordings from a speaker with PD were analyzed for F2 diphthong transitions, which revealed evidence of increased articulatory excursions following intensive voice treatment, even though no therapy exercises involved articulation.

Discussion

These data reveal altered vocal tract behavior when the larynx is the target of therapy. When treating hypokinetic dysarthria via loudness, it can be reasoned that increasing vocal effort by definition demands more forceful respiratory drive and is likely to result in increased vocal tract activity, because loudness can be considered a 'global' control variable (Dromey et al., 1995). But in the case of SD, where the treatment is not behavioral, the improvements in articulation suggest that smooth phonatory function may be essential to rapid and skilled articulatory movements (Tingley & Dromey, 2000). The MTD data set supports the hypothesis that reducing tension in the laryngeal musculature allows freer articulator movements.

References

Dromey, C., Ramig, L.O., & Johnson, A.B. (1995). Phonatory and articulatory changes associated with increased vocal intensity in Parkinson disease: A case study. *Journal of speech and hearing research, 38*, 751-764.

Tingley, S. & Dromey, C. (2000). Phonatory-articulatory relationships: Do speakers with spasmodic dysphonia show aberrant lip kinematic profiles? *Journal of Medical Speech Language Pathology, 8*, 249-252.

THE INTERNAL STRUCTURE OF PHONETIC REPRESENTATIONS: EVIDENCE FROM NEUROPHONETICS

Wolfram Ziegler
Clinical Neuropsychology Research Group,Neuropsychological Department City Hospital Bogenhausen, München, Germany
wolfram.ziegler@extern.lrz-muenchen.de

Short Overview

One of the assumptions underlying neurolinguistic and neurophonetic research is that the patterns of impaired language production we observe in patients with neurogenic speech and language disorders may provide information about the structure and the nature of linguistic representations. From this viewpoint, neurogenic speech disorders may inform us about the make-up of the phonological and the phonetic representations of words and phrases.

This presentation will give an overview of the neurophonetic evidence of what the building blocks of phonetic plans or speech motor programs in adult speakers might be. Most of this evidence comes from research on apraxia of speech, i.e., from a speech disorder which occurs after lesions to the left cerebral hemisphere and – in theoretical approaches – is usually associated with the phonetic encoding stage of spoken language production.
In the «Nijmegen-model» (Levelt et al., 1999), *syllables* are claimed to play a crucial role as speech motor units. Through extensive motor learning during speech acquisition, the most frequent syllables of a language get stored as *phonetic plans*. Hence, the theory assumes that speech motor programs are stored in a *syllable lexicon* (Cholin et al., 2005), with a neural locus in the premotor cortex. A role of syllable-sized units in speaking has also been confirmed by analyses of syllable frequency and syllable structure effects on speech errors in patients with apraxia of speech, i.e., in patients who have lesions in cortical areas anterior to the left face motor cortex (Aichert & Ziegler, 2004).

An important assumption of Levelt's theory is that locally represented, holistic phonetic units are accessed and then aligned in a linear sequence before they can be articulated. Models postulating a linear ordering of a fixed type of phonetic primitives, e.g. syllables, meet several limitations which will be discussed on the basis of recent neurophonetic data. Several sources of evidence suggest that syllable-sized phonetic plans may not be holistic units, but in themselves be structured hierarchically. Moreover, structures overarching several syllables to form metrical feet and phonological words are probably also part of the phonetic representations governing fluent articulation (Ziegler, 2005). On the basis of speech error data from apraxic speakers, a probabilistic, non-linear model of the make-up of phonetic plans will be proposed which integrates different layers, from articulatory gestures up to metrical feet, into a hierarchically nested motor representation.

References

Aichert, I. & Ziegler, W. (2004). Syllable frequency and syllable structure in apraxia of speech. *Brain and Language, 88,* 148-159.
Cholin, J., Schiller, N. O., & Levelt, W. J. M. (2005). The preparation of syllables in speech production. *Journal of Memory and Language, 50,* 47-61.
Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1-38.
Ziegler, W. (2005). A nonlinear model of word length effects in apraxia of speech. *Cognitive Neuropsychology, 22*, 603-623.

VOWEL PRODUCTION AND PERCEPTION IN APRAXIA OF SPEECH

Adam Jacks, Thomas P. Marquardt
The University of Texas, Austin, USA
adamjacks@gmail.com

Introduction

Acquired apraxia of speech (AOS) is a disorder of speech motor control characterized by segmental distortions, impaired prosodic patterns, and difficulty initiating speech. Behavioral characteristics of AOS reflect inefficient translation of well-formed phonological representations into spatio-temporal parameters of movement. Linguistic and auditory-perceptual deficits often co-exist in AOS but are believed to be concomitant features not integral to the speech motor control disorder. Perceptual processing nevertheless may play an important role in speech motor control, as recent theoretical models have posited auditory-based perceptual maps as the higher-order representational structure from which articulatory parameters are derived (Guenther et al., 2006). The purpose of this study was to examine articulatory targeting and auditory perception for vowels in adults with AOS to provide evidence for the underlying nature of the speech motor control impairment.

Methods and Results

Five adults with AOS and five non-brain-damaged (NBD) participants participated in the study, with diagnosis of AOS based on results from the Western Aphasia Battery and Apraxia Battery for Adults. Participants produced three front vowels /ɪ, ɛ, æ/ in four word length conditions. The first two formants were determined for each vowel production at vowel onset and vowel nucleus. Acoustic distance ratios (ADR), a measure of acoustic differentiation, were calculated as the ratio of Euclidean distance between formants in adjacent vowel categories to the within category formant variation. Perception of the same vowels was tested in /hVd/ context using standard vowel identification and same/different discrimination procedures. Analysis of vowels revealed productions that were less acoustically differentiated for AOS participants than NBD participants. Perceptual categorization was impaired in four of the five AOS participants, but same-different discrimination was unimpaired. Auditory perceptual decisions were not significantly related to vowel distinctiveness measures.

Discussion

The findings suggest that AOS is a disorder specific to speech motor targeting, notwithstanding the frequent co-occurrence of perceptual and linguistic errors commonly associated with the disorder. The evidence supports previous claims that AOS can occur in a relatively isolated form, although such cases are rare. The lack of a direct relationship between production and perceptual abilities should not overshadow the important fact that four of five AOS participants had impaired perceptual identification. Taken together with normal same-different discrimination abilities, the identification results suggest impaired of auditory-verbal short-term memory as a component of broad-based mild aphasic impairment in most speakers with AOS. Future studies are planned to explore the relationship between the function of neural regions with various speech, language, and cognitive abilities, with the eventual goal of understanding the neural underpinnings of acquired apraxia of speech.

References

Guenther, F.H., Ghosh, S.S., & Tourville, J.A. (2006). Neural modeling and imaging of the cortical interactions underlying syllable production. *Brain & Language*, *96(3)*, 280-301.

SPEECH PRODUCTION OF DEAF CHILDREN FOLLOWING COCHLEAR IMPLANTATION

Marie-Eve Bouchard[1], Lucie Ménard[1], Marie-Thérèse Le Normand[2], Henri Cohen[1]
[1]*University of Quebec in Montreal, Canada,* [2]*INSERM Robert Debré Hospital, Paris, France*
m-e.bouchard@videotron.ca

Introduction

Because of their hearing limitations, prelinguistically deaf children (PDC) present major difficulties to learn to speak and consequently, to be understood orally. By stimulating the auditory nerve, cochlear implant (CI) permits PDC to gain a better access to spoken language. The current investigation was undertaken to evaluate whether or not implanted PDC improve the quality of their speech. More precisely, this study had three objectives: (1) to compare the judgement made by listeners on the speech produced by implanted PDC; (2) to evaluate the difference in the perception of vowels and consonants; (3) and to clarify the influence of age at implantation and mode of communication on the inter-rater agreement.

Methods and Results

Two groups of judges composed of two EXP and 40 INEXP judges were asked to identify the vowels or the consonants that composed the speech stimuli. These stimuli were stop C-V syllables extracted from the spontaneous conversation of 12 PDC who were implanted between 26 and 78 months. Speech productions were recorded 6, 18 and 36 months post-surgery. It was hypothesized that improvement in the pronunciation should result in an increase in EXP and INEXP agreement for the identification. Repeated measures ANOVAs revealed a clear effect of time on the overall intelligibility scores, especially concerning the low central vowels. More limited progresses were observed for consonants. Age at implantation and mode of communication did not influence the performances.

Discussion

The results of the current investigation demonstrated that the effect of contextual information on perception of implanted PDC speech cannot be overlooked for; when sublexical units were presented, improvements were not observed for all classes of phonemes. Additionally, no significant effect was obtained with respect to the influence of the age at implantation and mode of communication. Vowels were the only ones to demonstrate prominent progress. Thus, overall results suggest that the auditory information provided by the CI supports the acquisition of global speech skills but that perception may not be sufficient to refine the articulatory strategies required to make linguistic units deprived of contextual information more intelligible to either EXP or INEXP listeners.

References

Peng, S.C., Spencer, L.J., & Tomblin, J.B. (2004). Speech intelligibility of pediatric cochlear implant recipients with 7 years of device experience. *Journal of Speech, Language, and Hearing Research*, *47,* 1227-1236.

Geers, A., Spehar, B., & Sedey, A. (2002). Use of speech by children from total communication programs who wear cochlear implants. *American Journal of Speech-Language Pathology, 11,* 50-58.

THE IMPACT OF LATERAL TONGUE RESECTIONS ON MIDSAGITTAL TONGUE MOVEMENT DURING SPEECH

Orchid Rastadmehr[1], Tim Bressmann[1], Elizabeth Ackloo[1] and Jonathan C. Irish[2]
[1]University of Toronto, Department of Speech-Language Pathology, [2]Wharton Head and Neck Centre, Princess Margaret Hospital, Toronto, ON, Canada
orchid.rastadmehr@utornto.ca

Introduction

Tongue cancer is relatively rare but has particularly pernicious functional consequences for affected individuals. The standard treatment of tongue cancer involves resection (glossectomy) and reconstruction, often accompanied by radiotherapy. The surgical resection and reconstruction can cause speech deficits in the glossectomy patients. It is usually assumed that the loss of tongue tissue will be proportional to the loss of function and movement range (Dios et al., 1994). The present research aimed to provide an accurate description on the functional consequences of a partial lateral tongue resection on midsagittal tongue movement in speech.

Methods and Results

Tongue movement of ten oral cancer patients, who underwent partial lateral tongue resections, and six adults with normal speech were examined. The participants were asked to read the Grandfather Passage and to repeat VCV syllables. Their midsagittal tongue movement during the speech tasks was visualized using an ultrasound machine. We used the Ultra-CATS software to measure the distance from the transducer to the midsagittal tongue surface. The average movement velocity of the tongue surface was calculated by dividing the total distance by the total time. Vowel spaces were evaluated by measuring the first and second formant frequencies of the second vowels in VCV syllables.

The tongue height and the mean velocity of the midsagittal tongue movement increased significantly after glossectomy (0.036 m/sec. before and 0.045 m/sec. after the operation). The average velocity was significantly higher in patients after glossectomy than in the adults with normal speech (0.034 m/sec.). Over 87% of the preoperative vowel space was preserved postoperatively.

Discussion:

The results indicated that the partial glossectomy patients compensated for the loss of lateral tongue tissue by elevating their midsagittal tongues to a higher level and increasing the speed of their tongue movement during speech. Because of their increased effort in tongue movement, the patients retained most of their preoperative vowel space. The average level of tongue elevation was greater and the movement velocity was higher in patients after glossectomy than in adults with normal speech. These are interesting findings in relation to the method of speech therapy required after an oral cancer resection.

References:

Dios, P. D., Feijoo, F., Ferreiro, M. C., & Alvarez, J. (1994). Functional consequences of partial glossectomy. *International Journal of Oral & Maxillofacial Surgery*, *(52)*, 12-14.

WHAT IS THE NATURE OF THE MOTOR SPEECH DISORDER IN FOREIGN ACCENT SYNDROME?

Karen Croot[1,2,3], Sallyanne Palethorpe[2,3], Jeremy Tree[4,] Kathleen Rastle[2,3,5], Lisa Stephenson[1,3], Bronwyn Deacon[1], Ruth Brunsdon[2,6], Kathleen Bakker[6]

[1]Department of Psychology, University of Sydney, Australia, [2]Macquarie Centre for Cognitive Science, Macquarie University, Australia, [3]Speech Hearing and Language Research Centre, Macquarie University, Australia, [4]Department of Psychology, Exeter University, England, [5]Department of Psychology, Royal Holloway, University of London, England, [6]Rehabilitation Department, The Children's Hospital at Westmead, Australia

karenc@psych.usyd.edu.au

Introduction

People with foreign accent syndrome (FAS) experience changes in their speech production after neurological damage such that listeners hear a different regional or foreign accent. Investigation typically also shows features of dysarthria and/or apraxia of speech (AOS). Three accounts of FAS attribute the disorder to (1) atypical articulatory tension (Graff-Radford et al., 1986), (2) disruption to pre-stored articulatory gestural scores yielding phonetic alterations and reduced coarticulation (Whiteside & Varley, 1998), or (3) multiple impairments to the speech motor control system (Kurowski et al., 1996). This study aimed to test these accounts using acoustic investigations of two speakers with FAS.

Methods and Results

NC, a male monolingual speaker of Australian English, acquired a «North American» accent for 5 months due to motor vehicle accident (MVA) at 13 years. Analysis of NC's F0 and acoustic vowel space in the F1/F2 plane indicated high laryngeal and supralaryngeal tension. NJ, a female monolingual English speaker from Cornwall UK, acquired a "central European" accent due to MVA at 52 years. NJ's vowel and consonant production 4 months post-accident also suggested raised articulatory tension. Over the next 3 years, her consonant and vowel production suggested NJ increasingly adopted a lax articulatory style, and that initially impaired coarticulation improved over time. Five years post-accident, NJ's speech involved substantial reorganisation of hypothesised premorbid articulatory strategies.

Discussion

We conclude that FAS potentially involves atypical vocal tract tension (especially at onset), associating FAS with spastic dysarthria. Impaired coarticulation can also be present, as in AOS. Evidence for both in NJ's case suggests NJ had sustained multiple speech motor control impairments, supporting account (3). Any speech motor impairments resulting in speech changes that fall within the phonetic parameters of natural languages may yield FAS.

References

Graff-Radford, N.R., Cooper, W.E., Colsher, P.L., & Damasio, A.R. (1986). An unlearned foreign "accent" in a patient with aphasia. *Brain & Language*, *28(1)*, 86-94.

Kurowski, K.M., Blumstein, S.E., & Alexander, M. (1996). The FAS: A reconsideration. *Brain and Language*, *54*, 1-25.

Whiteside, S. P. & Varley, R. A. (1998). A reconceptualisation of apraxia of speech: A synthesis of evidence. *Cortex*, *34*, 221-231.

SPONTANEOUS SPEECH OUTCOMES FROM SELF-MONITORING THERAPY IN A CASE OF APRAXIA OF SPEECH

Marleen Corijn[1], Nick Miller[2], Frank Paemeleire[1,3], Marijke Van Rumst[1,3]
[1]General Hospital Maria Middelares Ghent, Belgium , [2]University Newcastle-on-Tyne, United Kingdom, [3]Arteveldehogeschool Ghent, Belgium
m.corijn@skynet.be

Introduction

Postma and Oomen (2005) argue that the role of speech self-monitoring abilities is largely ignored in speech-language therapy and stress the need to target such processes. In this case (DB, female, 61 yrs), we studied whether therapy focused on self-monitoring alone can reduce overt error repairs in spontaneous speech.

Methods and Results

Baseline and 4,18,22 weeks post onset (p.o.) measurements consisted of the AAT, motor speed (verbal and non-verbal diadochokinesis-DDK) and processing speed (SCOLP/ speed of comprehension: Baddeley et al, 1992). Three speech-therapists made a consensus-inventory (audiosample of AAT interview) of the pre-articulatory (initial sound prolongations, (un)filled pauses) and the post-articulatory behaviours (restarts, perceived speech derailment) and measured rate of speech (syll/s) .

Therapy (3x50 min /week between 4 -18 weeks p.o.) centred on self-monitoring (error identification; inhibition of overt repair; strategies for reformulation/correction) .

From baseline assessment (4 weeks) to treatment termination (18 weeks) speech rate increased (2.6-3.1 syll/s); overt self corrections/ restarts decreased (3.63-1.73%), as did sound prolongations, pauses with schwa insertion. Overt segmental errors (0.28-1.21%) and silent pauses (0.7-2.76%) increased. Speed of comprehension rose (31-40 correct in 2 min), but DDK measures remained stable. After 4 weeks without speech therapy (22 weeks) there was some regression towards baseline values.

Discussion

This case suggests that a focus on self-monitoring can influence the proportion of self-corrections, restarts and proportion of filled pauses. It did not in this case reduce the number of perceived segmental errors. The fact that performance deteriorated again after therapy finished suggests intervention was having some effect, but that self-monitoring had not become fully automatic again. We argue for the importance of self-monitoring but highlight the questions that will have to be answered by more research to reach definitive conclusions.

References

Baddeley, A.D., Emslie, H., & Nimmo-Smith, I. (1992). *The Speed and Capacity of Language Processing (SCOLP) Test*. Bury St Edmunds, Suffolk: Thames Valley Test Company.

Postma, A. & Oomen, C.C.E. (2005). Critical issues in speech monitoring. In : R.J. Hartsuiker, R. Bastiaanse, A. Postma, & F. Wijnen (Ed.) *Phonological Encoding and Monitoring in Normal and Pathological Speech*, 157-166.Hove, New York: Psychology Press.

MOTOR PROGRAMMING OF SPEECH AND FINGER MOVEMENTS IN APRAXIA OF SPEECH: A REACTION TIME APPROACH

Edwin Maas[1,2], Donald A. Robin[1,2], Véronique Steinhauer[1], Kirrie J. Ballard[3], Curt E. Magnuson[4], David L. Wright[4]

[1]Speech, Language, and Hearing Sciences, San Diego State University, [2] Language and Communicative Disorders, University of California, San Diego, [3] Speech Pathology and Audiology, University of Iowa, [4] Health and Kinesiology, Texas A&M University, USA

maas@rohan.sdsu.edu

Introduction

Apraxia of Speech (AOS) is a motor programming disorder, and motor programming involves specifying temporal-spatial structure of movements. This study examined motor programming of time in AOS and controls, framed within a recent programming model (Klapp, 1995) that fractionates motor programming of serial movements into two processes, INT and SEQ. INT organizes unit-internal structure, can be preprogrammed, and is sensitive to unit complexity: INT takes longer for complex than for simple units. SEQ sequences units into correct serial order by retrieving preprogrammed units from the buffer, cannot be pre-programmed, and is sensitive to number of units: SEQ takes longer for movements containing more units. This study addresses 1) the hypothesis that AOS is a deficit in INT, not SEQ, 2) the hypothesis that AOS involves a modality-independent deficit in temporal programming, and 3) differences between speech and finger motor programming in unimpaired participants.

Methods and Results

We examined the duration of each process as a function of movement duration and number of elements using finger (button press) or speech (syllable /ba/) movements. A reaction time paradigm (Wright et al., 2004) was used to assess processing time: Study Time (ST) captures INT, Reaction Time (RT) captures SEQ. We investigated each process in each modality in patients with AOS and in control subjects.

Control subjects revealed the expected sequence length effect on RT for finger movements but not for speech movements. Data from four patients with AOS show that ST is longer than for controls but RT is similar to controls for both speech and finger movements.

Discussion

The results suggest, first, that AOS represents a motor programming deficit localized to the INT stage, while SEQ appears intact. Second, this INT-deficit was found for both speech and finger movements, supporting the hypothesis that AOS involves a central (not speech-specific) deficit in motor programming. Third, the finding of a sequence length effect on RT for finger movements but not for speech sequences suggests that integration of syllables can be completed in advance, unlike button presses which require on-line sequencing (SEQ).

References

Deger, K. & Ziegler, W. (2002). Speech motor programming in apraxia of speech. *Journal of Phonetics*, *30*, 321-335.

Klapp, S.T. (1995). Motor response programming during simple and choice reaction time: the role of practice. *Journal of Experimental Psychology: Human Perception and Performance*, *21(5)*, 1015-1027.

Wright, D.L., et al. (2004). Long-term motor programming improvements occur via concatenating movement sequences during random but not blocked practice. *Journal of Motor Behavior*, *36(1)*, 39-50.

AUDIO-VISUAL MATCHING ABILITIES VARY WITH MOTOR ABILITIES IN PATIENTS WITH APHASIA AND APRAXIA OF SPEECH

Gabriele Schmid, Wolfram Ziegler
EKN – Clinical Neuropsychology Research Group, Neuropsychological Dept., City Hospital Munich-Bogenhausen, Germany
Gabi.Schmid@extern.lrz-muenchen.de

Introduction

Audiovisual speech perception mechanisms provide evidence for a supra-modal nature of phonological representations, and a link of these mechanisms to motor representations of speech has been postulated. This leads to the question if in aphasic patients and in patients with apraxia of speech the implicit knowledge of audiovisual relationships is preserved and if impaired motor skills as in orofacial apraxia and apraxia of speech interact with the perceptual abilities in these patients. Moreover, it is unknown if the audiovisual processing of mouth movements has a specific organisation in the speech as compared to the nonspeech domain.

Methods and Results

A discrimination task with speech (syllables) and nonspeech stimuli (sound producing mouth movements, e.g clicks) was applied in four presentation modes: auditory, visual, bimodal and cross-modal. We investigated 14 healthy persons and 14 patients with aphasia and / or apraxia of speech. Additionally we collected clinical data concerning the patients' speech and nonspeech motor abilities.

*Results. P*atients made substantially more errors than normal subjects on both the speech and the nonspeech stimuli, in all presentation modalities. Normal controls made only few errors on the speech stimuli, regardless of the presentation mode, but had a high between-subject variability in the cross-modal matching of nonspeech stimuli. The patients' cross-modal processing of nonspeech stimuli was mainly predicted by lower face apraxia scores, while their audiovisual matching of syllables was predicted by word repetition abilities and the presence of apraxia of speech.

Discussion

The results of this study showed that impaired speech perception in aphasia is located at a supramodal representational level. Additionally, the results revealed that in patients with lesions to the left hemisphere audio-visual matching abilities vary with their clinically verified motor abilities. This might be due to a production-perception overlap since internal simulation of the oral gestures might be used to facilitate their perception. A further implication of the data is that audiovisual processing is different for speech and nonspeech oral gestures and is determined by the behavioural significance of the actions.

References

Callan, D.E., Jones, J.A., Munhall, K.G., Callan, A.M., Kroos, C., & Vatikiotis-Bateson, E. (2003). Neural processes underlying perceptual enhancement by visual speech gestures. *Neuroreport*, *14*, 2213-2218.

Hickock, G. & Poeppel, D. (2004). Dorsal and ventral streams: a framework for understanding aspects of the functional anatomy of language. *Cognition*, *92*, 67-99.

Schmid, G. & Ziegler, W. (in press). Audio-visual matching of speech and non-speech oral gestures in patients with aphasia and apraxia of speech. *Neuropsychologia*.

INFLUENCES ON SPEECH OUTPUT IN ACQUIRED APRAXIA OF SPEECH: A COMPARISON OF ENGLISH AND GERMAN

Nicole Lallini, Nick Miller
University of Newcastle-upon-Tyne, United Kingdom
Nicole.Theiner@ncl.ac.uk

Introduction

The nature of breakdown in apraxia of speech (AoS) continues to be a subject of debate. One inroad into establishing where disruption lies concerns which output variables influence performance. This study exploits the fact that English and German share a large number of (near) homophones. We compared the influence of the language-specific variables word frequency, phonotactic predictability (PROB), lexicality and phonological neighbourhood density (ND) on accuracy of word repetition in German and English speakers.

Methods and Results

7 German and 7 matched English speakers with AoS, repeated words that are (near)-homophones across German and English. Accuracy in repeating these items was investigated in relation to differences in language-specific properties Moderate correlations existed between accuracy on English and German. There was slight similarity between patients, but within-language chance-corrected correspondence on average was greater within than between-languages. Differences between languages were significantly related to word frequency and length-corrected phonotactic predictability, but not phonological neighbourhood density. Effects of differences in word frequency and phonotactic predictability were independently significant; the effect of number of neighbours remained non-significant. Correlations for accuracy for speakers combined across both languages for number of phonemes, syllables and consonant clusters in target words showed accuracy related to all three. As predictors in multiple regression, there remained significant independent effects of the number of phonemes and of clusters but no effect of the number of syllables.

Discussion

It appears that only PROB has a significant effect on production accuracy in these speakers with output impairment. This effect is facilitatory in that words with higher PROB are produced more accurately than those with low PROB. Furthermore, the effect of PROB does not seem to lie at the motor execution level. A strong cross-language relationship would have been observed instead of only a moderate one. In contrast, ND does not have a significant effect on the accuracy of productions of these German and English speakers.

Different factors might have played a role in why we did not observe a significant effect of ND. First, participants with impaired output were included as opposed to healthy speakers in Vitevitch and Luce's (1999) study. Furthermore, the effect of ND might lie at the level of lexical access which we did not tap into because we employed a repetition task.

References

Bailey, T.M. & Hahn, U. (2001). Determinants of Wordlikeness: Phonotactics or Lexical Neighbourhoods. *Journal of Memory and Language*, *44*, 568-591.

Luce, P.A. & Pisoni, D.B. (1998). Recognizing spoken words: The neighborhood activation model. *Ear and Hearing*, *19*, 1-36.

Vitevitch, M.S. & Luce, P.A. (1999). Probabilistic phonotactics and neighborhood activation in spoken word recognition. *Journal of Memory and Language*, *40*, 374-408.

VARIABILITY OF VOICE ONSET TIME, VOWEL DURATION AND UTTERANCE DURATION IN APRAXIA OF SPEECH

Anita van der Merwe, Jackie Grimbeek
University of Pretoria, South Africa
anita.vandermerwe@up.ac.za

Introduction

Variability in motor output may reflect the flexibility, but also the instability of the motor system. An understanding of variability of speech signs in apraxia of speech may be instrumental in a better understanding of this speech disorder.

The purpose of this study was to determine if individuals with apraxia of speech and matched control individuals with no speech disorders showed differences in variability in voice onset time, vowel duration and utterance duration during repeated production of utterances with different syllable structures.

Methods and Results

Five speakers with apraxia and three matched control individuals took part in the study. Four individuals had acquired apraxia of speech and one was a ten-year-old boy with childhood apraxia of speech. All the individuals with apraxia of speech had received speech therapy. Voice onset time (VOT), vowel duration, and utterance duration were measured acoustically during six repetitions of 20 nonwords. Four nonwords in each of five different syllable structures were used as test stimuli. These syllable structures were constructed as follows: C1V1C1V2, C1V1C2V2, C1V1C2V2C3, C1V1C2, and C1V1C2V2C3V3C4. VOT of the first consonant, duration of the first vowel and of the CVCV or CVC part of the nonwords were measured.

The apraxic speakers showed significantly less variability in VOT than the normal speakers. VOT remained within the normal range during most repetitions, but inconsistent VOT errors occurred. In contrast, vowel and utterance duration were significantly more variable in the apraxic speakers than in the normal speakers.

Discussion

The results seem to indicate that interarticulatory synchronization as measured in VOT is affected differently from segmental duration in apraxia of speech. Reduced variability of VOT may reflect an attempt to consciously control the temporal parameters within the motor plan of (initial) voiced consonants. There is, however, inadvertent loss of voluntary control that occurs inconsistently. The variability in duration may reflect the instability of the motor system.

References

McNeil, M.R, Robin, D.A, & Schmidt R.A. (1997). Apraxia of speech: Definition, differentiation, and treatment. In M.R. McNeil (Ed.) *Clinical management of sensorimotor speech disorders*, 311-344. New York: Thieme.

Baars, B.J. (1992) *Experimental slips and human error: Exploring the architecture of volition*. New York: Plenum Press.

AN ELECTROPALATOGRAPHY STUDY INTO THE EFFECTS OF LSVT ON ARTICULATION IN PARKINSON'S DISEASE

Ineke Mennen[1], Fiona Gardiner[2], Linda Morrison[1], Duncan Gray[2], Sharon Sutherland[2], Rhona Brown[2], John Broughton[2], Alan Wrench[1]
[1]Queen Margaret University College, Edinburgh, [2]NHS Highland, Inverness , Scotland
imennen@qmuc.ac.uk

Introduction

The Lee Silverman Voice Treatment (LSVT) is an intensive therapy programme which aims to reduce speech effects of hypokinetic dysarthria in individuals with Parkinson's Disease (PD). This technique teaches people with PD to improve loudness and voice quality through the concept of 'thinking loud' when speaking. Despite its focus on phonation it is reported that LSVT may also improve articulation in clients with PD, but objective evidence for this claim is lacking (Ramig et al., 1995).

Electropalatography (EPG) is a technique which measures the location and timing of the tongue contact with the hard palate during speech. This study seeks to investigate by means of EPG analysis whether there is empirical evidence of articulatory changes after LSVT.

Methods and Results

Three participants with idiopathic PD were fitted for an EPG palate. Baseline measurements were taken prior to the start of LSVT, involving an intelligibility test and EPG readings (of a word list, some short sentences, and a short text, whilst wearing the EPG palate). The participants then engaged in the LSVT programme (4 weeks of 4 hourly sessions per week). Immediately after the completion of LSVT the participants provided the same speech samples for post-treatment analysis. Pre- and post- LSVT data collection took place at the same time of day to control for possible effects of medication taken by the participants.

We present results temporal measurements for the target phonemes /t/ and /k/ taken from 10 repetitions of the words *toe* and *key*, and spatial measurements for the target phonemes /t/, /k/ and /s/ of the words *toe*, *key* and *seed* of two speakers before and after LSVT. We will also present spatial measures of /t/ in final word position.

Results showed that there were no significant changes in the spatial configurations of /t/, /k/ and /s/ in word initial position after LSVT. However, there were significant differences in temporal measurements of the articulatory changes before and after LSVT. Furthermore, some qualitative changes were also observed in spatial measures of final /t/.

Discussion

Results suggest that some articulatory changes did take place after LSVT but that careful consideration needs to be given to the type of measurements and data suitable to capture these changes. The spatial and temporal results will be discussed in relation to pre- and post-intelligibility ratings.

References

Ramig, L.O., Countryman, S., Thompson, L.L., & Horii, Y. (1995). Comparison of two forms of intensive speech treatment for Parkinson Disease. *Journal of Speech and Hearing Research*, *38 (6)*,1232-1251.

CONFIRMATION OF SILENT ARTICULATORY ATTEMPTS/ STARTERS IN ACQUIRED APRAXIA OF SPEECH

Carly Bartle, Justine Goozée, Bruce Murdoch
School of Health and Rehabilitation Sciences, The University of Queensland, Australia
c.bartle@uq.edu.au

Introduction

Prolonged response latencies are commonly observed in acquired apraxia of speech (AOS). Little research to date, however, has investigated their underlying nature. Given that *audible* initiation attempts and starters have been reported in AOS, the aim of the present study was to use electromagnetic articulography (EMA) to investigate the presence of, and the kinematic properties of *silent* articulatory attempts and starters in AOS. Their influence on response latency and proceeding target consonant productions was also investigated.

Methods and Results

Tongue-tip and tongue-back movement of one apraxic speaker (NR; aged 52 years; 11 years post-onset left CVA) and an age-gender matched control group (n = 3; mean age = 51.33 years; SD = 2.52) was recorded using the AG-200 EMA system (Carstens Medizinelectronik) during word-initial consonant productions (/t, s, k/) and their preceding silent articulatory attempts/starters. Response latencies greater than 1 000 ms were recorded for approximately 33% of NR's responses. Similarly, 40% of NR's total target consonant productions were preceded by a silent articulatory attempt/starter, either before (e.g., '[silent attempt/starter] a tar') or after (e.g., 'a [silent attempt/starter] sarge') the vowel. The kinematic properties of NR's silent articulatory attempts/starters differed significantly from those recorded during her target consonant productions, and from those recorded for the control group during target consonant productions. The presence of silent articulatory attempts/starters had varying effects on the proceeding target consonant productions.

Discussion

The results indicate that silent articulatory attempts and starters, in part, may be able to account for prolonged response latencies in AOS. Interestingly, the movement profiles of NR's silent articulatory attempts and starters differed from those of her target consonant productions, and of the target consonant productions of the control group. The presence of silent articulatory attempts and starters may reflect a need for additional sensory and/or proprioceptive feedback during speech, and provides additional support for a motoric account of AOS.

References

Duffy, J.R. (2005). *Motor speech disorders: Substrates, differential diagnosis, and management (2nd ed.).* Philadelphia, PA: Mosby.

McNeil, M., Odell, K.H., Miller, S.B., & Hunter, L. (1995). Consistency, variability, and target approximation for successive speech repetitions among apraxic, conduction aphasic, and ataxic dysarthric speakers. *Clinical Aphasiology*, *23*, 39-55.

SPATIAL CHARACTERISTICS OF SPEECH MOVEMENTS IN ALS

Yana Yunusova[1], Jordan Green[1], Antje Mefferd[1], Laura J. Ball[2], Gary L. Pattee[2]
[1]*University of Nebraska, Lincoln,* [2]*University of Nebraska Medical Center, USA*
yunusova@unlserve.unl.edu

Introduction

Movement reduction has been hypothesized to be one of the primary factors in the reduction of acoustic/ phonetic contrasts and speech intelligibility in dysarthria due to Amyotrophic Lateral Sclerosis (ALS). However, only limited empirical evidence exists documenting the extent and nature of movement reduction in dysarthric speech. Westbury et al (in preparation) showed smaller than normal total articulatory working spaces for the tongue in speakers with ALS. Yunusova (2005) reported differences in movement extents during vowels between speakers with ALS and normal controls as a function of the articulator, vowel and phonetic context. The current study aims to extend previous findings in order to understand the relationship between changes in spatial characteristics (e.g., size, shape, and location) of speech movements over the course of disease progression.

Methods and Results

Speakers with ALS were recorded longitudinally reading at their normal rates. A 3-D motion capture system was used to record movements of the lips and jaw. Movement sizes were estimated as the volume of the articulatory working spaces for each articulator. Movement path shapes were determined based on ranges of articulatory movements in x, y and z dimensions. Locations of the word-related movements were expressed relative to the centroid of the total articulatory working space. Speech intelligibility was also estimated for each recording session. Preliminary findings based on data from one speaker, suggested that decrements in speech intelligibility were associated with changes in spatial measures for the jaw and upper lip but not the lower lip. The total and word-related articulatory working areas increased in size for the jaw and upper lip markers. These changes appeared proportionally similar between x, y, and z dimensions. Centralization of the word-related movements toward the centroid of the total movement distribution were observed for the jaw and upper lip.

Discussion

Overall, preliminary results showed that the spatial measures of size, shape, and location were sensitive to the presence of motor speech disorder due to ALS and related to speech intelligibility estimates within a speaker. The measures differed by word, and articulator and are expected to vary across speakers. Results will be evaluated with respect to interpretability of the selected measures. The findings will be further discussed in relation to acoustic observations reported in the literature and issues of dysarthria progression in ALS.

References

Westbury, J.R., Weismer, G., Weiss, C., Yunusova, Y., & Bunton, K. (in prep.). Articulatory correlates of speech intelligibility in speakers with Parkinson disease and Amyotrophic Lateral Sclerosis.

Yunusova, Y. (2005). Articulatory movements during vowels in speakers and dysarthria and normal controls. *Unpublished doctoral dissertation*, University of Wisconsin – Madison.

VOWEL LENGTHS IN INITIALLY SHORTENING WORD PARADIGMS IN THREE KINDS OF APHASIC SPEECH

Diana Van Lancker Sidtis[1,2], Daniel Kempler[3]
[1]New York University, [2]Nathan Kline Institute, [3]Emerson College NY, USA
drv1@nyu.edu

Introduction

Timing abnormalities have been reported for aphasic speech (Sidtis & Van Lancker Sidtis 2003). This study sought to compare three kinds of aphasic speakers, on whom full structural and functional imaging data were available, on a temporal parameter known to be robust in normal speech: initial shortening.

Methods and Results

Four Broca, Wernicke, and anomic aphasic patients (evaluated on the Western Aphasia Battery) and matched normal-control subjects were studied. For patients, F-18 FDG PET scans using left/right ratios in a regions of interest (ROI) measure and CT scanning were utilized, rating fifteen ROIs (Metter et al., 1990). Subjects produced spoken repetitions of paradigms such as: *zip*, *zipper*, *zippering*. The vowel nuclei in the stem and two derived forms were measured. An ANOVA comparing groups by words by derived form resulted in significant main effects of group, word, and form. PET and CT ratings showed temporoparietal damage, greater for the Wernicke's group, and the groups differed in left-to-right asymmetry.

Discussion

All groups showed initial shortening in derived word paradigms, but abnormal patterns were seen in Broca aphasia as in previous studies (Danly & Shapiro, 1982; Seddoh, 2004). Vowel durations were lengthened in the Wernicke group. Similar lengthening is seen in delayed auditory feedback, suggesting a role of impaired monitoring. In brain imaging ratings, Wernicke's aphasia showed only mild to moderate asymmetry frontally, suggesting that in that group, frontal cortical function for motor production may be preserved but affected by loss of input information.

References

Danly, M. & Shapiro, B. (l982). Speech prosody in Broca aphasia. *Brain and Language*, *16*, 71-l90.

Metter, E. J., Hanson, W., Jackson, C, Kempler, D., Van Lancker, D., Mazziotta, J., & Phelps, M. (1990). Temporoparietal cortex in aphasia. *Archives of Neurology*, *47*, 1235-1238.

Seddoh, S. A. (2004). Prosodic disturbance in aphasia: speech timing versus intonation production. *Clinical Linguistics & Phonetics*, *18*, 17-38.

Sidtis, J. J. & Van Lancker Sidtis, D. (2003). A neurobehavioral approach to dysprosody. *Seminars in Speech and Language*, *24 (2)*, 93-105.

ELECTROPALATOGRAPHIC ASSESSMENT OF TONGUE-TO-PALATE CONTACTS IN DYSARTHRIA ASSOCIATED WITH FRIEDREICH'S ATAXIA

Joanne Mohr[1], Bruce Murdoch[1], Louise Cahill[1], Deborah Theodoros[1], Martin Delatycki[2]
[1] *School of Health and Rehabilitation Sciences, University of Queensland, Australia*
[2] *Murdoch Children's Research Institute, Royal Children's Hospital, Victoria, Australia*
b.murdoch@uq.edu.au

Introduction

Friedreich's ataxia (FRDA) is one of a heterogeneous group of degenerative spinocerebellar disorders. Although not always present at the disease onset, dysarthria is a common feature of FRDAS with a prevalence of >90% noted in some studies. Perceptual studies have revealed marked impairment in articulatory, respiratory and velopharyngeal function in FRDA. The aim of the present study was to use electropalatography to examine the spatial characteristics of tongue-to-palate contacts exhibited by a group of five subjects with FRDA.

Methods and Results

Diagnosis of FRDA was confirmed by molecular genetic assessment. Five non-neurologically impaired adults served as control subjects. Two single syllable real words consisting of CVC construction were read aloud six times by each subject while wearing an EPG palate. The word initial consonants for analysis included the alveolar stop /t/ and the velar stop /k/. Each of the target words was preceded by a neutral *schwa*. The results revealed a number of significant changes in the tongue-to-palate contacts utilised by the FRDA participants compared to controls. In particular the contact patterns for the FRDA subjects were consistently much more asymmetrical with the majority of FRDA participants exhibiting a greater number of contacts on the left hand side of the EPG frame for both the alveolar stop and velar stop. Compared to controls the FRDA participants consistently showed a decrease in the centre of gravity (COG) values during the alveolar stop production, indicative of a posterior shift to the tongue to palate contact. In contrast, the FRDA participants all demonstrated an increase in COG values for velar stop production indicative of an anterior shift in contact compared to controls.

Discussion

The tongue-to-palate contact patterns were deviant in several ways compared to controls that might contribute, at least in part, to their perceived articulatory deficit. In particular the major deviations included a higher degree of asymmetry in the contact pattern and centralisation of the contacts with respect to anterior/posterior direction during consonant production.

References

Cahill, L.M., Theodoros, D.G., Murdoch, B.E., & MacMillan, J. (2003). Physiological features of dysarthria in Friedreich's ataxia. *Asia Pacific Journal of Speech, Language and Hearing*, *8*, 221-228.

RISPERIDONE EFFECT ON SPEECH MOTOR CONTROL IN HEALTHY ADULTS

SunYoung Oh[1], Henri Cohen[1,2,4], Brendon Binneman[3], Emmanuelle Pourcher[4], Kara Chappie[3], Ichiro Arano[3], Michael S. Cannizzaro[2,5]

[1]Cognitive Neuroscience Center, Université du Québec à Montréal, [2]NeuroSolutions, Montreal, Qc. Canada, [3]Pfizer Global Research & Development, Groton, CT, USA, [4]Movement and Memory Disorders Center, Polyclinique Sainte Anne, Quebec, Qc, Canada, [5]The University of Vermont, Burlington, VT, USA

henri.cohen@uqam.ca

Introduction

Psychoactive drugs, such as neuroleptics, may induce extra-pyramidal symptoms which include motor control difficulties such as slowness of movement, increased tone, tremor and restlessness. Neurodegenerative disorders affecting extra-pyramidal structures such as Parkinson's disease have also been reported to induce similar abnormalities in complex sequences of motor behaviour including speech motor control. Patients with such motor disorders often present with slow, inaccurate speech production and can be greatly affected by repetition and rapidity in movement.

Diadochokinesis, a task requiring rapid repetitions of a monosyllable has been used as an index of motor speech impairment as it calls for the contribution of motor speech control systems. This study investigates how speech motor performance in healthy adults is affected by risperidone, a psychoactive drug.

Methods and Results

Eleven male French participants, aged 25 to 40, were seen under three random drug conditions (placebo, 1mg, 3mg risperidone). Diadochokinesis (DDK) was used to examine rapidity of oral motor during 5-second repetitions of /pa/ at a controlled moderate rate and then as fast as possible. Speech was recorded at 3-hour and 6-hour post-dosing. DDK protocols were computed using Motor Speech Profile software.

Results showed a significant decrease in DDK rate at 3 mg in faster speech; DDK period also showed a tendency of increased intervals under drug conditions compared with placebo.

Discussion

Risperidone interferes significantly with articulatory mobility, especially at 3 mg, in young healthy adults for DDK performance. Although rather protective considering the induction of gross motor function slowness, this dose may induce disturbances in complex speech motor behaviour. Acoustic speech measurements could therefore provide a more effective and sensitive tool to track neurological side effects of neuroleptics. This is a novel report of a neuroleptic effect on the speech of healthy adults.

References

Kent, R.D., Kent, J.F., & Rosenbek, J.C. (1987). Maximum performance tests of speech production. *Journal of Speech and Hearing Disorders*, *52 (4)*, 367-87.

Takano, A., Suhara, T., Ikoma, Y., Yasuno, F., et al.(2004). Estimation of the time-course of Dopamine D_2 receptor occupancy in living human brain of plasma pharmacokinetics of anitpsychotics. *International Journal of Neuropsychopharmacology*, *7*, 19-26.

THE EFFECTS OF ACUTE DOPAMINE ANTAGONISM ON SPEECH PRODUCTION IN HEALTHY ADULTS

Michael S. Cannizzaro[1,2], Henri Cohen[2,3,4], Brendon Binnemen[4], Ichiro Arano[4], Eamannuelle Pourche[5]

[1]The University of Vermont, Burlington, VT, USA, [2]NeuroSolutions, Montreal, [3]Département de Psychologie, Centre de Neuroscience de la Cognition, Université du Québec à Montréal, Qc,Canada., [4]Pfizer Global Research & Development, Groton, CT, USA, [5]Polyclinique Ste-Anne, Quebec, Qc, Canada.

Michael.cannizzaro@uvm.edu

Introduction

Antipsychotic medications are associated with extrapyramidal symptom side effects (EPS) including tremor, dystonia, bradykinesia, and akathisia, even following a single dose (Tandon et al., 2002). Considerable overlap between EPS of antipsychotic therapy and manifestations of Parkinson's disease (PD) are commonly observed during subjective clinical neurological observation. A number of acoustic measures of speech and voice have demonstrated sensitivity in detecting variations in motor symptomatology and medication fluctuations in persons with PD (Goberman et al, 2002; Harel et al., 2004; Ramig et al., 2004). Therefore, quantitative acoustic assessment of speech in persons experiencing EPS was explored as a means of identifying the impact of acute dopamine modulation on speech motor production and as a means of detecting pharmacologically induced EPS liability.

Methods and Results

Twelve healthy male subjects between the ages of 25 & 40 years participated in this randomized, placebo controlled, 2-way-crossover design. Participants received Risperidone (3mg) or placebo and speech recordings were made at baseline (just prior to dosing) and 3 hours post dosing.

Voice acoustic measurements were significantly sensitive to modulations in dopamine previously related to EPS in the 3 mg condition; while no significant differences were found between the baseline and 3 hour time point during the placebo condition for these same measures.

Discussion

Therefore, acoustic measurement of speech and voice may provide an objective method for the detection of EPS liability in novel pharmacological compounds. Additionally, this methodology is robust to the challenges and difficulties inherent in studying PD by providing specific information regarding the impact of acute striatal dopamine modulation on speech production.

References

Goberman, A.M. & Coelho, C.A. (2002). Acoustic characteristics of Parkinsonian speech II: L-Dopa related fluctuations and methodological issues. *NeuroRehabilitation*, *17(3)*, 247-54,

Harel, B., Cannizaro, M., Cohen, H., & Snyder, P. (2004). Acoustic characteristics of Parkinsonian speech: a potential biomarker of early disease progression and
treatment. *Journal of Neurolinguistics*, *17(6)*, 439-453.

Tandon, R. & Jibson, M.D. (2002). Extrapyramidal side effects of antipsychotic treatment: scope of problem and impact on outcome. *Annals of Clinical Psychiatry*, *14(2)*, 123-9.

COGNITIVE-LINGUISTIC PERFORMANCES IN TREMOR-DOMINANT AND AKINETIC RIGID DOMINANT SUBTYPES OF PARKINSON'S DISEASE

Cynthia O'Donoghue, Christopher Watts, Jeffrey Marler
James Madison University, Harrisonburg, Virginia, USA
odonogcr@jmu.edu

Introduction

Crosson (1985) reported indirect influences of subcortical areas such as the basal ganglia and the thalamus on cortical language centers. More recent literature (Georgopoulos, 2000; Sanes & Donoghue, 2000) suggested a crucial link between cognitive-linguistic status and motor presentation. Known cognitive-linguistic findings in Parkinson's disease (PD) include difficulty comprehending high-level stimuli (Berg et al., 2003; Lewis et al., 1998), alterations in naming, producing definitions and constructing sentences (Lewis et al., 1998), as well as disturbances in memory, attentional resource allocation, and mental processing speed (Berg et al., 2003; Watts & Degenais, 2001).

Cognitive-linguistic performances in PD require further investigation. This research is particularly needed if efforts are further focused on potential variants of PD - specifically, Tremor-Dominant (TD) and Akinetic Rigid Dominant (ARD) subtypes. The purpose of this pilot study was to investigate potential differential cognitive-linguistic profiles in TD and ARD subtypes of PD.

Methods and Results

Subjects with a neurologist's confirmed diagnosis of PD were evaluated completing:

– A comprehensive motor speech analysis including, but not limited to, diadochokinesis, laryngeal DDK, frequency range and F2 transitions.
– The *Cognitive-Linguistic Quick Test* (CLQT) (Helm-Estabrooks, 2001) to assess the domains of attention, memory, executive functions, language and visuospatial skills.

Eight male subjects compromised of four TD PD subtype and four ARD PD subtype were identified using the *Unified Parkinson Disease Rating Scale* (UPDRS) motor phenotype scores. Mean age and time post-onset between the TD and ARD groups were comparable. Results of this pilot study revealed notable trends for differing cognitive-linguistic profiles between TD and ARD groups. The ARD group scores were consistently lower than the TD group scores on all domains of the CLQT. Domains of attention, executive functions and visuospatial skills yielded the greatest differences. Continued investigation with increased sample size and statistical comparison is merited.

References

Watts, C. & Dagenais, P. (2001). Effects of attentional load on speech rate reduction in subgroups of speakers with Parkinson's disease. *Journal of Medical Speech-Language Pathology*, *9*, 55-61.

Duffy, J. (2005). *Motor Speech Disorders: Substrates, Differential Diagnosis, and Management*. Elsevier Mosby: St. Louis.

PREVALENCE AND PATTERNS OF INTELLIGIBILITY DECLINE IN PARKINSON'S DISEASE

Nick Miller[1], David Burn[2], Anna Jones[3], Tony Hildreth[4], Emma Noble[1], Maria Wolters[5]
[1]University of Newcastle, [2]General Hospital Newcastle, [3]University of Northumbria, [4]Royal Hospital Sunderland, [5]Queen Margaret College, Edinburgh, United Kingdom
Nicholas.Miller@ncl.ac.uk

Introduction

We address two issues surrounding communication changes in Parkinson's disease (PD): how many people experience speech-voice changes; does speech decline in parallel with overall disease progression? The prevalence of speech problems in PD is placed variously between 40-90%. Variability reflects sampling biases and varying assessment focus. We sought a clinically, functionally useful estimate based on a community survey using diagnostic intelligibility testing (Kent et al., 1989) and speaker self ratings and comparing results with other disease and demographic variables.

Methods and Results

41 healthy controls; 126 individuals with idiopathic PD (mean age 71.45, SD 8.61) recruited through community clinics. Assessed in an off state on a diagnostic intelligibility test, scored by 'everyday listeners' hearing audio-recordings; Unified Parkinson's Disease Rating Scale (UPDRS) II and III; and Hoehn and Yahr (HY) rating of overall disease severity. Self rating of satisfaction with speech. Naive listeners rated speakers on scale of 'disorderedness' on basis of connected speech sample.

69% speakers with PD fell below the 75th%ile of the control group, 41% >-1SD below the control mean. Self-ratings of satisfaction: only 8% felt satisfied. Only 4% rated as 'does not have a speech disorder'. Significant correlation of HY and UPDRS scores with intelligibility. Neither HY nor UPDRS accounted for more than a fraction of the variance. Relationship of intelligibility level to age borderline; non-significant for disease duration.

Discussion

Concerning how many people with PD have intelligibility difficulties that might require active treatment attention, the answer here lies between 41-69% depending on how one argues the cut-off between PD and control speakers. Taking self and other perceived levels of satisfaction the figures are closer to 90-95%. This is in keeping with studies indicating perceived communication problems in people who score well within the normal range on formal testing and vice versa (Miller et al 2006). We discuss these results in terms of issues in intelligibility assessment; and who is or is not a candidate for speech pathology intervention in PD.

References

Kent, R., Weismer, G., Kent, J., & Rosenbek, J. (1989). Toward Phonetic Intelligibilit Testing in Dysarthria. *Journal of Speech and Hearing Disorders*, *54(4)*, 482-499.

Miller, N., Noble, E., Jones, D., & Burn, D. (2006). Life with communication changes in Parkinson's disease. *Age and Ageing*, *35*, 1-5.

DISFLUENCIES IN THE SPONTANEOUS SPEECH OF NORMALLY DEVELOPED AND SLI CHILDREN

Mária Gósy[1], Viktória Horváth[2] & Katalin Csabai[3]
[1]Linguistics Institute HAS, [2]ELTE University,
[3]National Speech Diagnostic Center, Budapest, Hungary
gosy@nytud.hu

Introduction

Spontaneous speech is characterized by several phonetic processes like co-articulation, the variability of the phonetic form of words, and by various types of disfluency phenomena. Disfluency is the result of an error occurring at some level of speech planning. Children with relatively weak language skills often demonstrate higher levels of disfluency, however, the literature on this topic shows conflicting findings with respect to the relationship between language impairment and disfluency. This study analyses whether children with long-standing histories of language impairment are more disfluent, and display different or a wider range of disfluencies than age-matched peers who exhibit typical development. Our hypothesis was that Hungarian-speaking speech-impaired children of the tested age would show more types of and more frequent disfluencies due to the rich morphology of Hungarian.

Methods and Results

The types and the frequency of unplanned interruptions of spontaneous speech within two groups of preschool children were analysed. Diagnosed speech- and language-impaired children (SLI) participated in one of the groups while normally developed children made up the second (control) group. Spontaneous speech was recorded for all subjects under the same conditions. Their recorded and digitalized speech was analyzed in acoustic-phonetic, phonological and grammatical terms focusing on fluency.

On average, normally developed children's utterances were longer, relatively more fluent, contained more lexemes and were syntactically more complex (i.e. followed the rules of the Hungarian language more closely) than those of the SLI children as expected. Analysis of the SLI children's spontaneous speech showed huge differences in terms of fluency, morphological and syntactic forms, complexity, number of lexemes used and in particular in the types and frequency of disfluencies which differed significantly between the two groups.

Discussion

These findings enable a hypothesis to be formulated explaining the differences in speech disfluencies between normally developed and SLI children, and speech planning and production processes of preschool children can be evaluated depending on existing speech and language disorders. Our results provide evidence of the different speaking strategies of the tested children. Implications for clinical intervention and future research will be discussed.

References

Bernstein Ratner, N. & Sih, C. (1987). Effects of gradual increases in sentence length and complexity on children's dysfluency. *Jouornal of Speech and Hearing Disorders*, *52*, 278–287.

Owen, A. J. & Leonard, L. B. (2002). Lexical diversity in the spontaneous speech of children with specific language impairment: application of D. *Journal of Speech, Language and Hearing Research*, *45*, 927-37.

LINGUAL KINEMATICS DURING SPEECH IN PERSONS WITH MULTIPLE SCLEROSIS

Bruce Murdoch, Justine Goozée
School of Health and Rehabilitation Sciences, University of Queensland, Australia
j.goozee@uq.edu.au

Introduction

Reports have highlighted that up to 50% of people with Multiple Sclerosis (MS) experience speech disturbances, with articulatory disturbances particularly common. There is a conspicuous paucity of studies, however, examining the physiological underpinnings of dysarthria associated with MS. Physiological investigations of tongue function using non-speech tasks have revealed reductions in tongue strength, endurance, and rate of repetitive movements, with preclinical signs of tongue dysfunction identified also in non-dysarthric speakers with MS. There is much debate, however, as to how these nonspeech measures relate to, or affect, actual articulatory movements performed during speech. The present study aimed to directly investigate tongue movements during speech in persons with MS using electromagnetic articulography (EMA).

Methods and Results

Participants included two adults with MS and dysarthria, five non-dysarthric adults with MS, and 14 non-neurologically impaired adults. Tongue tip and tongue body movements during sentence productions were recorded using an AG200 EMA system (Carstens Medizinelektronik). Two of the participants with MS, one of whom was judged to be dysarthric, exhibited increased durations. The other participant with dysarthria exhibited increased values for velocity, acceleration, deceleration and distance; the effects of which may have counteracted to result in a comparable duration to the control group at least for the alveolar sentence. A similar pattern of interaction between kinematic parameters was found for one of the MS participants without dysarthria, who exhibited increased speed and distance parameters, resulting in a comparable duration to the control group. The remaining three non-dysarthric participants with MS exhibited comparable values to the control group for each of the kinematic parameters recorded.

Discussion

Increased kinematic parameter values were exhibited by both participants with MS and dysarthria. In addition, subclinical kinematic disturbances, characterised also by increased kinematic parameter values, were identified using EMA for two of the five participants with MS who were judged perceptually to be non-dysarthric. The increased velocity, acceleration, distance and duration measures suggest that the participants with MS may have been overarticulating, perhaps as a compensatory strategy for motor control disturbances and/or in an attempt to maintain articulatory precision and intelligibility.

References

Murdoch, B.E., Theodoros, D.G., & Ward, E.C. (2000). Articulatory and velopharyngeal dysfunction in multiple sclerosis. In: B. E. Murdoch & D. G. Theodoros (Eds.) *Speech and Language Disorders in Multiple Sclerosis*, 47-63. London: Whurr Publishers.3

EFFECTS OF BACKGROUND NOISE, LISTENER CONTEXT, AND SPEECH TASK ON SPEECH INTENSITY IN PARKINSON S DISEASE

Bon-Hi Moon[1], Scott Adams[1,2], Mandar Jog[2]
[1]*School of Communication Sciences and Disorders, London, United Kingdom*
[2]*Department of Clinical Neurosciences University of Western Ontario, Ontario Canada*
sadams@uwo.ca

Introduction

Hypophonia or low speech intensity is a very common feature of the hypokinetic dysarthria associated with Parkinson's disease (PD). A few preliminary studies have suggested that the type of speech task, listener context, and level of background noise may have a significant impact on the evaluation of hypophonia in PD (Kempler & Van Lancker, 2002; Ho et al., 1999). The purpose of the present study was to systematically examine the separate and combined effects of multi-talker background noise, speech tasks, listener context, and requests for clarification on speech intensity in PD.

Methods and Results

Ten control and 10 hypophonic PD subjects performed three speech tasks (reciting a memorized sentence, reading aloud, and engaging in conversation) under two multi-talker noise conditions (50 and 65 dB SPL). These tasks were performed alone and with a listener present. In a final condition, participants were intermittently asked for clarification of their utterances. Average speech intensity (dB SPL) was obtained for each utterance. A series of 3-way ANOVAs were used to evaluate the differences in tasks, conditions and groups. In general, PDs and controls showed a 'Lombard effect' that was reflected by a significant increase in speech intensity as the background noise increased from 50 to 65dB. Changing the speech task also had a significant effect on speech intensity in PDs and controls. Reciting a memorized sentence elicited the highest speech intensity, followed by reading aloud, and then engaging in conversation. The listener conditions also had a significant effect on speech intensity in both the PDs and controls. Both participant groups had greater speech intensity when alone than when a listener was present. PDs and controls both showed an increase in speech intensity when they received requests for clarification. Overall, it was found that the PD group spoke with significantly less speech intensity than controls for most of the experimental conditions. Despite this lower speech intensity, PD participants had relatively normal patterns of intensity regulation in response to changes in the intensity of background noise, different speech tasks, and requests for clarification.

Discussion

In general these findings suggest that individuals with PD show a normal pattern of intensity regulation but with an "overall gain reduction" for intensity. These results appear to be analogous to the reduced range of movement and "overall scale reduction" that is found for limb movements in PD. The results of this study should have important implications for the development of new methods of assessing and treating hypophonia in PD.

References

Ho, A.K., Bradshaw, J.L., Iansek, R., & Alfredson, R. (1999). Speech volume regulation in Parkinson's disease: implicit cues and explicit instructions. *Neuropsychologia*, *37*, 1453-1460.

Kempler, D. & Van Lancker, D. (2002). Effect of speech task on intelligibility in dysarthria: a case study of Parkinson's disease. *Brain and Language*, *80*, 449-464.

EFFECTS OF THALAMIC DEEP BRAIN STIMULATION ON VOCAL, ORAL AND UPPER LIMB ESSENTIAL TREMOR

Nicole Howitz[1], Scott Adams[1,2], Andrew Parrent[2]
[1]School of Communication Sciences and Disorders, [2]Department of Clinical Neurosciences
University of Western Ontario, London, Ontario Canada
howitz_nicole@yahoo.co.uk

Introduction

Thalamic deep brain stimulation (DBS) is frequently used to treat essential tremor (ET) of the upper limbs but rarely used to treat essential oral/vocal tremor. Investigations of the effects of thalamic DBS on oral and vocal tremor are very limited. The purpose of the present study was to examine the effect of thalamic DBS on vocal and oral essential tremor using acoustic and kinematic measures, clinical rating scales, perceptual ratings and patient self-rating scales. This study also compared the effects of thalamic DBS on vocal, tongue, jaw, head, limb and hand tremor.

Methods and Results

Six subjects who had received bilateral (five subjects) or unilateral (one subject) thalamic DBS for their ET were studied. Subjects were examined in a stimulator 'on' condition and a stimulator 'off' condition. The on-off stimulator evaluations included instrumental measures, clinical rating scales, patient self-rating scales and perceptual voice and speech ratings.

The stimulator 'on' condition was associated with a significant improvement in vocal and oral tremor for the instrumental measures of tremor amplitude, and the clinical ratings of tremor severity. Thalamic DBS had a greater and more consistent effect on vocal and jaw tremor than on tongue tremor. Perceptual speech ratings showed a slight reduction in speech intelligibility for the stimulator 'on' condition. The stimulator 'on' condition was associated with a significant improvement in upper limb tremor for the instrumental measures, clinical ratings, functional tasks and self-ratings.

Discussion

The results of this study show that thalamic DBS for limb ET can produce significant reductions in vocal and oral tremor. These improvements were associated with minimal effects on speech intelligibility. In general, these results are consistent with previous research and provide support for a focus on vocal and jaw tremor as primary treatment targets in future thalamic DBS research.

References

Carpenter, M.A., Pahwa, R., Miyawaki, K.L., Wilkinson, S.B., Searl, J. P., & Koller, W.C. (1998). Reduction in voice tremor under thalamic stimulation. *Neurology*, *50*, 796-798.

Duffy, J.R. (1995). *Motor speech disorders: Substrates, differential diagnosis, and management*. St. Louis: Mosby.

Sataloff, R.T., Heuer, R.J., Munz, M., Yoon, M.S., & Spiegel, J.R. (2002). Vocal tremor reduction with deep brain stimulation: A preliminary report. *Journal of Voice*, *16*, 132- 135.

AUDITORY – VISUAL INTEGRATION DURING SPEECH PERCEPTION IN CHILDREN WITH SPEECH PRODUCTION DISORDERS

Nancy Bouwens[1], Leenke van Haaften[1,2], Lian Nijland[2] , Ben Maassen[2]
[1]*Radboud University Nijmegen;* [2]*Radboud University Nijmegen Medical Centre, The Netherlands*
L.vanHaaften@cukz.umcn.nl

Introduction

In face-to-face conversations, perception of speech is a combination of hearing the voice and seeing the lip movements. Good auditory and visual speech perception and auditory-visual integration are needed for correct speech production. During early childhood, normally developing infants are constantly observing and imitating what they hear and see, which is often absent in children with speech production disorders. In this study auditory-visual integration during speech perception is tested in children with speech production disorders.

Since this study is the first on this subject, it is to hard make hypotheses about the findings. Earlier results showed that children with speech disorders have difficulties with auditory-only processing. On auditory-visual integration two hypotheses are possible, either less or more integration in children with speech disorders compared to normally speaking children. This will be discussed in more detail below.

Methods and Results

Participants are 26 Dutch children (aged 4;7 to 8;0 years) with speech production disorders ('Developmental Apraxia of Speech' or 'Phonological Disorders') and age-matched normally developing children. Auditory(A)-visual(V) integration is tested using the well-known McGurk paradigm (McGurk & MacDonald, 1976), in which incongruent McGurk-stimuli A[apa]-V[aka] result in the integrated percept [ata]. Besides the auditory-visual integration tasks, consisting of incongruent as well as congruent A[apa]-V[apa] and A[aka]-V[aka], also unimodal stimuli (A-only or V-only) were administered to these children.

Results show that the children with speech production disorders have less correct responses on the unimodal stimuli. This confirms earlier findings on difficulty with auditory stimuli. On the incongruent stimuli, the children with speech disorders show higher percentages integration responses.

Discussion

Preliminarily, it seems that children with speech production disorders have more integration responses as a result of a compensation strategy for the existing auditory processing deficits. This result disputes the suggestion by Hayes, Tiippana, et al. (2003) who reasoned that (in children with learning disorders) difficulties in auditory processing may lead to an increased cognitive demand which results in less integration. The alternative hypothesis that children with speech production disorders integrate more in order to compensate for their inferior auditory skills, seems to be more evident in this study.

References

Hayes, E.A., Tiippana, K.N., Nicol, T.G., Sams, M., & Kraus, N. (2003). Integration of heard and seen speech: a factor in learning disabilities in children. *Neuroscience Letters*, *351*, 46-50.
McGurk, H. & MacDonald, J. (1976). Hearing lips and seeing voices. *Nature*, *264*, 23-30.

KINEMATIC MEASUREMENTS OF DIADOCHOKINETIC PERFORMANCES IN CHILDREN WITH DAS OR PD

Renate van den Berg[1], Lian Nijland[2], Ben Maassen[2]
[1]Utrecht University, [2]Radboud University Nijmegen Medical Centre, The Netherlands
r.j.c.vandenberg@students.uu.nl

Introduction

Children with developmental apraxia of speech (DAS) display difficulties with planning, automating and programming speech. Acoustic and perceptive data about the speech showed that difficulties in sequence and timing seem to be the basis in DAS (Nijland, 2003). In contrast to DAS, children with phonological disorder (PD) seem to be distorted in phonological encoding, a process previous to motor planning and programming. Based on acoustic and perceptive data only, this distinction is often inconclusive. In this study, kinematic data are collected in children with DAS or PD in order to get a more detailed understanding of these speech disorders. We hypothesized that children with DAS display a different pattern of the articulatory movements when compared to children with PD and typically developing children, since children with DAS experience difficulties with diadochokinesis (DDK).

Method

Kinematic data were collected in 10 children (5;11 to 8;9 years old) with speech disorders DAS or PD and 6 children (6;4 to 9;8 years old) with typical speech development. Speech language pathologists distinguished the children with a diagnosis of DAS or PD. Additionally, we collected extensive speech data to confirm the diagnosis. Movements of the articulators in several speech tasks are measured two-dimensionally using Electromagnetic Midsagittal Articulography. The tasks consisted of mono-, bi-, and trisyllabic productions with consonants /p/, /t/ and /k/ (DDK). The collected data includes the displacement (D) and peak velocity (PV) of the lower lip closing movement for the /p/. The pathological group was divided into a group that could and a group that could not produce /pataka/-utterances.

Results and Discussion

Preliminary results show that both pathological groups display increasing values for amplitude when compared to the controls and decreasing values of peak velocity.

Furthermore, the higher mean jitter ratio and scanning index, indicating variability of either speech rate or amplitude and peak velocity, demonstrate more variability in the speech of the pathological groups. Variable (C) which is deduced from PV and D; PV/D=1/T*C (Munhall et al., 1985) indicates the extent of stiffness in the children's speech. Surprisingly the group that could not produce /pataka/ shows in the mono-syllabic condition a fixed pattern of stability while the other two groups do not. This rigid manner of speech execution is in contrast to the variability as indicated by the mean jitter ratio and scanning index.

References

Nijland, L. (2003). *Developmental apraxia of speech: Deficits in phonetic planning and motor programming*. PhD-thesis, Nijmegen.

Munhall, K.G., et al. (1985). Characteristics of Velocity Profiles of Speech Movements. *Journal of Experimental Psychology: Human Perception and Performance*, *11(4)*, 457-474.

THE COEFFICIENT OF VARIATION RATIO DETERMINED USING AUTOMATIC SPEECH RECOGNITION

John-Paul Hosom[1], Lawrence D. Shriberg[2], Jordan R. Green[3]
[1]*Oregon Health & Science University,* [2]*University of Madison, WI,*
[3]*University of Nebraska, Lincoln, USA*
hosom@cslu.ogi.edu; shriberg@waisman.wisc.edu; jgreen4@unl.edu

Introduction

Childhood Apraxia of Speech (CAS) continues to be challenging to study, in part due to a lack of consensus on the features that define it. We have previously reported diagnostic accuracy findings for one possible acoustic marker of CAS, the Coefficient of Variation Ratio (CVR: Shriberg, Green, *et al*., 2003). The CVR of an utterance is defined as the *coefficient of variation* of pause event durations (CV-Pause) divided by the coefficient of variation of speech event durations (CV-Speech). In the prior study, speech and pause events were identified primarily based on differences in signal amplitude using an interactive Matlab-based algorithm. This method, termed the Speech Pause Algorithm (SPA), was evaluated on a corpus containing speech samples from 30 children with typical speech acquisition (TS), 30 children with speech delay (SD), and 15 children suspected to have CAS. This method resulted in effect sizes (ES) of 0.72 and 0.71 for participants with TS/CAS and SD/CAS, respectively. The aim of the present study is to determine the applicability of automatic speech recognition (ASR) techniques to the computation of the CVR.

Methods and Results

An automatic speech-recognition system that identifies six manners of articulation, silence, and noise was applied to the same 75 conversational speech samples used in the original 2003 study. These eight recognized classes were mapped to either "speech" or "pause" events. In contrast to procedures used in the original study, speech and pause events less than 50 msec in duration were merged with neighboring events.

The ASR-based computation of the CVR yielded an ES of 0.68 comparing TS and CAS subjects, and an ES of 1.07 for SD and CAS subjects. The CV-Speech values had ES values of 0.95 and 1.04 for TS/CAS and SD/CAS, respectively, although there is the possibility of a confounding age effect. The correlation between ASR-based and SPA-based CVR values for participants with CAS was 0.74, and correlation for all participants was 0.54.

Discussion

ASR techniques appear to be applicable to the computation of the CVR marker, although differences in the ASR and SPA approaches yielded somewhat different CVR rankings and values. The presentation will discuss strengths and weaknesses of the ASR approach. Both CVR methods appear to discriminate participants with less variable duration of speech events, providing acoustic support for the percept of isochrony in children suspected to have CAS.

References

Shriberg, L. D., Green, J. R., Campbell, T. F., McSweeny, J. L., & Scheer, A. (2003). A diagnostic marker for childhood apraxia of speech: The coefficient of variation ratio. *Clinical Linguistics and Phonetics*, *17*, 575-595.

ACOUSTIC AND PERCEPTIVE ANALYSES OF VOWELS IN SUSPECTED DEVELOPMENTAL APRAXIA OF SPEECH: A PILOT STUDY

Esther Franz[1], Klaus Willmes[2], Christiane Neuschaefer-Rube[1], Bernd J. Kröger[1]
[1]Department of Phoniatrics, Pedaudiology, and Communication Disorders, [2]Department of Neurology, University Hospital Aachen, Germany
esther.franz@web.de

Introduction

Developmental apraxia of speech (DAS) is more and more accepted as a self-contained speech disorder. It is the aim of this study to demonstrate typical features of vowel and diphthong articulation in DAS by means of quantitative acoustical and perceptual analysis.

Methods and Results

A corpus of isolated word production (100 items) evoked by picture naming was collected for a child (m, 5;2) with suspected DAS and a group of 7 controls (m, 4;10-5;2). Each word realisation was presented to 14 raters in order to judge the vowel or diphthong realisation (perceptual evaluation). The time course of the first two formants was extracted for each vowel or diphthong within 21 selected items for the DAS child and 7 controls (acoustical evaluation). Six parameters (i.e. the horizontal position, the slope, and the parabolic curvature for F1 and F2) were determined for the time interval of these items.

For each of the 100 items the amount of incorrect judgements was significantly higher for the DAS child then for each of the controls. For the DAS child 21 items were clearly identified as vowel misarticulations. The acoustic evaluation showed for each of the 21 items at least for one of the 6 acoustic parameters a significant excursion from the controls.

Discussion

On the basis of these data we hypothesise that incorrect realisations of vowels or diphthongs can be detected by quantitative perceptual as well as acoustic analysis. Thus in addition to consonantal features mentioned in literature so far, incorrect vowel or diphthong productions seem to be a potential clinical marker for DAS. In further studies it is planned to expand the corpus by data of articulation disorders in order to develop methods for differentiating DAS from articulation disorders.

References

Davis, B. L., Jacks, A., & Marquardt, T. P. (2005). Vowel patterns in developmental apraxia of speech: three longitudinal case studies. *Clinical Linguistics and Phonetics*, *19*, 249-74.

Shriberg, L. D., Aram, D. M., & Kwiatkowski, J. (1997). Developmental apraxia of speech: I Descriptive and theoretical perspectives. *Journal of Speech, Language, and Hearing Research*, *40*, 273-285.

Walton, J. H. & Pollock, K, E, (1993). Acoustic validation of vowel error patterns in developmental apraxia of speech. *Clinical Linguistics and Phonetics*, *7*, 95-111.

PRE-LINGUISTIC VOCALISATIONS OF CHILDREN WITH DEVELOPMENTAL APRAXIA OF SPEECH

Chantelle Highman[1, 2], Neville Hennessey[1], Suze Leitão[1], Jan Piek[1] & Mellanie Sherwood[3]
[1]*Curtin University,* [2]*Andrea Way Child Development Centre,*
[3] *State Child Development Centre, Perth, Western Australia*
C.Highman@curtin.edu.au

Introduction

Reduced babbling and restricted phonemic inventories have been reported as potential early features of disorders of speech motor control, particularly Developmental Apraxia of Speech (DAS) (Maassen, 2002). The present research project utilises a combination of retrospective parent report and detailed case study analysis design paradigms to investigate this association. Methodology and preliminary results for data obtained to date are reported.

Methods and Results

Study 1 used a detailed questionnaire completed by parents of children with a clinical diagnosis of DAS (n = 20) to quantify aspects of early development that have theoretical parallels with the disorder in older children. Results are compared to those obtained from parents of children with diagnosed Specific Language Impairment (SLI, n = 20), and typically developing speech and langauge (TD, n = 20), and report on early development, including the presence and age of emergence of reduplicated and variegated babbling, and parental perceptions of volubility in infancy. Preliminary results indicate that parents of children with DAS were more likely to report their child to have not made many sounds as a baby, and to have not babbled, than parents of both the SLI children and TD children, consistent with theoretical and clinical hypotheses, although other aspects of reported communication development were similar for the two clinical groups.

Study 2 involved a unique trio of children (4;1. 4;3, 4;6) who demonstrated features consistent with DAS, who, from being previously involved in a community speech pathology program, have early communication data available. These early measures will be analysed as case studies and compared to children who also participated in the earlier program and now present with delayed langauge and/or phonological disorders. Future data will include acoustic analyses on the children's performance on speech production tasks. In Study 3, a longitudinal design involving infants with a family history of DAS (n=6) is reported. Preliminay data on one case showing marked discrepencies in measures of communicative intent and early speech motor control suggest consistency with theoretical hypotheses.

Discussion

The use of a combination of retrospective parent report, case study analysis of retrospective data, and a prospective longitudinal design provides an insight into the potential earliest features of disordered speech motor control. Although data collection and analysis are not yet complete, preliminary results suggest support for the notion of a deficit that may originate with speech motor control.

References

Maassen, B. (2002). Issues contrasting adult acquired versus developmental apraxia of speech. *Seminars in Speech and Language, 23(4)*, 257-266.

INTENSIVE TREATMENT FOR SEVERE CHILDHOOD APRAXIA: AN EFFICACY STUDY

Edythe Strand, Ruth Stoeckel, Becky Baas
Mayo Clinic, Rochester, MN, USA
Strand.edythe@mayo.edu

Introduction

Evidence based practice has recently come to the forefront in the treatment of speech disorders (Robey, 2004). Unfortunately, the evidence for treatment efficacy in motor speech disorders in children is sparse, especially for childhood apraxia of speech (CAS). In the last ten years, only six studies of treatment effects have been published in CAS. Only four focused on speech production and only one of those was a controlled single subject design (Strand and Debertine, 2000). While such evidence is greatly needed and frequently called for, very few experimental studies are published. This poster reports data regarding initial treatment effects for 3 young non-verbal children with severe apraxia of speech. A rationale for the treatment approach is presented, based on particular assumptions regarding the processing deficits in CAS (Maassen, 2000; Caruso and Strand, 1999), and specific principles of motor learning.

Methods and Results

A treatment approach (Dynamic Temporal and Tactile Cueing), based on integral stimulation and incorporating a number of principles of motor learning was used. A single subject, multiple baseline (across behaviors) design was implemented for experimental control, and replicated across 3 children. Baseline data for experimental and control stimuli were collected over several sessions. Treatment was conducted on a changing set of utterances (as one utterance reached criteria, training was discontinued and another brought in). Probe data were collected at frequent intervals for treated and control items, as well as for maintenance performance. All interjudge reliability measurements to date have been over 80%.

All three children exhibited rapid change following the implementation of treatment. The degree of performance change was greater than that for control probes, and improvement was maintained for most but not all utterances.

Discussion

The data show this treatment to be efficacious in the treatment of children with severe apraxia of speech. While individual components of the treatment were not tested, the importance of frequent intensive practice, and the implementation of motor learning principles were shown to facilitate early speech production in children who had been previously unsuccessful in responding to therapy.

References

Caruso, A. & Strand, E. (1999) Definitions, Background and a Theoretical Framework. In Caruso, A. & Strand, E.A. (Eds.) *Clinical Management of Motor Speech Disorders of Children*. New York: Thieme.

Robey, R., (2004) A five-phase model for clinical-outcome research. *Journal of Communication Disorders*, *37,* 401-411.

Strand, E. & Debertine, P. (2000). The efficacy of integral stimulation intervention with Developmental Apraxia of Speech. *Journal of Medical Speech-Language Pathology*, *8(4)*, 295-300.

RESULTS OF INTEGRAL STIMULATION INTERVENTION IN THREE CHILDREN WITH CAS

Kathy J. Jakielski, Tricia L. Kostner, Cathy E. Webb
Augustana College, Rock Island, IL, USA
csdjakielski@augustana.edu

Introduction

Studies conducted by Rosenbeck, Lemme, Ahern, Harris, and Wertz (1973) and Strand and Debertine (2000) demonstrated the efficacy of using integral stimulation intervention in treatment of individuals with apraxia of speech. Additional intervention efficacy studies are needed to determine the applicability of this approach to a variety of children with CAS.

The purpose of the present study was to identify and quantify change in articulatory skills as a result of an integral stimulation method of intervention in three children from 7 to 9 years of age with moderate to severe CAS. Two hypotheses were tested.

1. There would be an increase in speech accuracy on experimental stimuli from the beginning to the end of the study, with minimal change in performance on control stimuli.
2. Following an 18-week withdrawal of intervention, previous progress on experimental stimuli would decrease in accuracy with no change in performance on control stimuli.

Methods and Results

A_1-B_1-A_2-B_2 multiple baseline withdrawal design was used. Two 16-session, 8-week intervention periods were separated by an 18-week period of no treatment. There were 6-8 experimental and 5 control sentences developed for each child, and each experimental sentence was practiced for 5 minutes in every intervention session using the integral stimulation approach. A scaled scoring system of 0, 1, and 2 was used to quantify production accuracy of experimental and control stimuli.

Results indicated that all children began the study largely unable to produce experimental and control stimuli with accuracy. By the end of the second intervention phase, all three children produced 93-100% of the experimental stimuli with full or partially accuracy (range of fully accurate productions = 39-72%; range of partially accurate productions = 24-54%). None of the children demonstrated significant improvement on control stimuli, although some improvement was noted on sentences that were similar to an experimental sentence.

Discussion

The children in the present study experienced greater articulatory accuracy on the expeirmental stimuli than on the control stimuli, and improvement was noted on all exprimental stimuli. The increases in articulatory accuracy are proposed to be evidence of motor learning attained by using integral stimulation methods in the children's speech intervention. Additional research on integral stimulation intervention might focus on larger groups of children, the rate at which cues are decreased, the optimal number of stimuli presented, and the effects of morphosyntactic complexity on progress in intervention.

References

Rosenbeck, J.C., Lemme, M.L., Ahern, M.B., Harris, E.H., & Wertz, R.T. (1973). A treatment for apraxia of speech in adults. *Journal of Speech and Hearing Disorders*, *38*, 462-472.

Strand, E.A. & Debertine, P. (2000). The efficacy of integral stimulation intervention with DAS. *Journal of Medical Speech-Language Pathology*, *8*, 295-300.

PRODUCTION ACCURACY AND DURATION OF EXPERIMENTAL WORDS WITH IAMBIC STRESS IN TYPICAL AND IMPAIRED SPEECH DEVELOPMENT

Fay Windsor[1], Nigel Hewlett[2], Fiona Gibbon[2]
[1]*Manchester Metropolitan University, United Kingdom,*
[2]*Queen Margaret University College, Edinburgh, Scotland*
f.windsor@mmu.ac.uk

Introduction

The production of words with iambic (weak-strong) stress can pose a particular challenge for young English-speaking children. There is a tendency for children below the age of 3 years to omit the weak syllable or to assimilate its duration to that of the following strong syllable. Significant improvement in the accuracy of stress placement has been reported in children aged between 2 and 3 years, and the ability to reduce the duration for the unstressed syllable has been shown to improve with increasing age. The overall accuracy of consonants does not appear to be affected by stress.

Goddell and Studdert-Kennedy (1993) (GSK) used nonsense disyllables with iambic stress to investigate gestural organisation in the speech of 2-year-olds. Few unacceptable utterances were reported. The aim of this study was to partially replicate GSK, focussing on production accuracy and duration of the experimental words.

Methods and Results

The participants were four 2-year-olds; four 4-year-olds; four 4-year-olds with impaired speech development; and four adults. The two youngest children in the study were followed longitudinally. There were six experimental words with iambic stress. The data were analysed perceptually for errors and omissions, and acoustically for duration.

The proportion of responses characterised by errors or omissions was .49 for the 2-year-olds; .02 for the 4-year-olds; and .48 for the children with speech impairment. Most errors and omissions could be attributed to the two youngest children in the study and one child with severe speech impairment. In general, all the children had longer durations than the adults.

The longitudinal data revealed that the two youngest children omitted more weak syllables at time 1 than time 2. In addition, durations were significantly longer at time 2 than time 1, and trade-off effects in production accuracy occurred between the strong and weak syllables.

Discussion

In contrast to GSK, a number of production errors and omissions were found. These could be attributed to three children: one 4-year-old child with severe speech impairment and two typically developing 2-year-olds. The similarities between these children provide tentative support for use of the term *speech delay*. The group data support the general assumption that duration decreases with increasing age. However, the longitudinal data showed a reversal in this trend for two children. If motor control for speech improves with age, additional factors may be required to account for this reversal. There may be trade-off effects in production accuracy between factors such as whole-word shape and segmental composition.

References

Goodell, E. W. & Studdert-Kennedy, M. (1993). Acoustic evidence for the development of gestural coordination in the speech of 2-year-olds: A longitudinal study. *Journal of Speech and Hearing Research*, *36(4)*, 707-727.

TRANSLATIONAL NEUROSCIENCE: PATTERNED SOMATOSENSORY STIMULATION TO ENTRAIN OROMOTOR ACTIVITY IN PREMATURE INFANTS

Steven M. Barlow[1,2,3], Donald S. Finan[4,5], Lana Seibel[1], Shinying Chu[1], Meredith Poore[1], Emily Zimmerman[1], Mimi Urish[1], Meredith Estep[2]
[1]Dept. Speech-Language-Hearing, [2]Neuroscience, [3]Human Biology, Univ. of Kansas, [4]Dept. Speech-Language-Hearing Sciences, [5]Center for Neural Science, Univ. of Colorado, USA
smbarlow@ku.edu

Introduction

Feeding competency is a challenging hurdle facing many premature babies, especially for those who have an extensive history of intubation due to respiratory distress syndrome (RDS). These preemies often lack a functional non-nutritive suck (NNS) or manifest oromotor dyscoordination which may persist well into early childhood and may lead to delays in the emergence of other oromotor behaviors. The lengthy intubation procedures cost the baby precious sensory and motor experiences during a critical period of brain development for oromotor pattern generation. A new therapeutic stimulation technique is described for entraining the suck central pattern generator (CPG) in premature infants at risk for significant oromotor dysfunction due to prolonged periods of sensory deprivation and neurological insult.

Methods and Results

Twelve RDS preemies with extensive oxygen history and no functional suck were administered entrainment therapy at 34 weeks gestational age. The synthesized NNS pattern was delivered through a pneumatically-coupled pacifier and consisted of a series of 6-cycle bursts (1.8 Hz pulse rate). A total of 34 NNS burst-pause trains were presented up to 4x/day over a 14-day period. The treated babies were compared statistically to a cohort of untreated RDS preemies and healthy PRETERM controls on several dependent measures, including NNS Bursts/min, Non-NNS Events/min, NNS Burst Cycles/min, Mean NNS Cycles/burst, and Total Mouthing Events/min. The patterned somatosensory input was highly effective in facilitating the suck CPG in RDS preemies, and led to competent oral feeds and shorter NICU stays.

Discussion

The suck CPG can be entrained in premature babies with a significant history of RDS and orosensory deprivation. The application of a salient mechanosensory pattern to the oral sensorium which mimics the NNS in infants represents an application in translational neuroscience based on the principles underlying the modulation of the human suck CPG.

References

Barlow S.M. & Estep M. (2006). Central pattern generation and the motor infrastructure for suck, respiration, and speech. Invited paper. *Journal of Communicative Disorders*.

Barlow, S.M., Finan, D.S., & Park, S.-Y. (2004). Central pattern generation and sensorimotor entrainment of respiratory and orofacial systems. In B. Maassen, R. Kent, H.F.M. Peters, P.H.M.M. van Lieshout, & W. Hulstijn (Eds.) *Speech Motor Control in Normal and Disordered Speech*, 211-224. Oxford: University Press.

ARTICULATION OF CLICKS IN CHILDREN WITH VELOCARDIOFACIAL SYNDROME

Fiona Gibbon[1], Alice Lee[1], Ivan Yuen[1], & Lisa Crampin[2]
[1]*Queen Margaret University College, Edinburgh,*
[2]*Glasgow Dental Hospital and Yorkhill Hospital, Scotland*
fgibbon@qmuc.ac.uk

Short Overview

We report electropalatographic (EPG) data on a rare type of compensatory articulation, namely clicks, in the speech of a girl (S) and a boy (E) with velocardiofacial syndrome. Clicks are complex speech sounds that under normal circumstances only occur in the languages of Southern Africa. Our observations were based on a list of sentences that both speakers read aloud. Results showed that S produced alveolar click [!] for /t/, /d/ and palatal clicks [ǂ] for /k/ and /g/ targets; whereas E produced bilabial clicks for /p/ and /b/, alveolar clicks for the alveolar stops and affricates, and palatal click for the velar stops. In addition, nasal clicks were found in speaker E to replace voiced /d/, /g/ and /dʒ/.

Timing and tongue-palate contact patterns from the EPG data revealed that the production of clicks always involved a sequence of two closures, one in the alveolar and the other in the velar region. On most occasions, the first phase of the click sequence involved alveolar closure. The second involved simultaneous alveolar and velar closures. The release of the alveolar closure resulted in an audible click sound. The final phase involved velar closure only.

The clicks showed by S and E were possibly learned mis-articulations that they used to produce plosives with strong bursts in the context of ongoing velopharyngeal inadequacy. Despite their mis-articulations, both S and E achieved the phonemic distinction in the place of articulation between the alveolar and velar plosives. In addition, E showed that voicing distinction was achieved occasionally by means of a nasal click.

References

Gibbon, F.E. & Crampin, L. (2002). Labial-lingual double articulations in cleft palate speech. *Cleft Palate Craniofacial Journal*, *39*, 40-49.

Heselwood, B. (1997). A case of nasal clicks for target sonorants: A feature geometry account. *Clinical Linguistics and Phonetics*, *11*, 43-61.

Ladefoged, P. & Maddieson, I. (1996). *Sounds of the World's Languages*. Oxford: Blackwell Publishers.

Ladefoged, P. & Traill, A. (1994). Clicks and their accompaniments. *Journal of Phonetics*, *22*, 33-64.

Sands, B. (1991). Evidence for click features: Acoustic characteristics of Xhosa clicks. *UCLA Working Papers in Phonetics*, *80*, 6-37.

SPEECH MOVEMENT CHARACTERISTICS IN CHILDREN WITH SPEECH DELAY

Lakshmi Venkatesh[1], Christopher A. Moore[1], Thomas F. Campbell[2], Lawrence D. Shriberg[3], Jordan R. Green[4]
[1]University of Washington, [2]University of Pittsburgh, [3]University of Wisconsin - Madison, [4]University of Nebraska - Lincoln, USA
lakshmiv@u.washington.edu

Introduction

Investigations of articulatory coordination of speech have quantified developmental changes in the coordinative organization of the lips and jaw in typically developing children (Green et al., 2002). Oral kinematic analyses have provided some evidence of disruptions in the organization of lips and jaw in children with motor speech disorders such as dysarthria and developmental apraxia of speech (Connaghan et al., 2000; Nijland et al., 2004). The current investigation was designed to describe in children with speech delay the speech movement characteristics of the lips and jaw during tasks involving rapid repetitive productions of syllables (diadochokinesis). Inherent task requirements of timing and sequencing of movement reversals in repetitive production of syllables provide a unique opportunity to observe physiologic adjustments by articulators and may reveal motor constraints in speech production in young children, including both typically developing children and those with speech delay.

Methods and Results

Participants included two groups of children aged 3-to-5 years: one group of children with typical speech (TS) and a second group of children with speech delay of unknown origin (SpD). Movement traces of upper lip, lower lip, and the jaw, produced during repetitive productions of syllables containing the bilabial consonant /p/, were extracted automatically from video recordings of each participant using a computer based movement tracking system. Movement stability for each articulator was measured across movement cycles within a single set of repetitions; this measure provided an index of articulator coordination during repetitive speech production. Results revealed that a subgroup of children with SpD exhibited greater articulator instability across repetitions in a trial, as compared with children with TS.

Discussion

The coordinative organization of the lips and the jaw appear to provide a distinctive indi-cation of speech delay in the context of typical development of speech motor control. The decreased movement stability of articulators across repetitive productions of syllables observ-ed in the typical-sounding speech of children with speech delay appears to exist at a subclinical level (i.e. below the perceptual threshold for disorder) and is consistent with the role of mo-tor capacities underlying the deficits associated with speech sound delay of unknown origin.

References

Connaghan, K.P., Moore, C.A., Reilly, K., Campbell, T.F., Green, J.R., & Steeve, R. (2000). Inter articulatory coordination in children with impaired speech motor control. Paper presented at the American Speech-Language Hearing Convention, Washington, DC.

Green, J.R., Moore, C.A., & Reilly, K.J. (2002). The sequential development of lip and jaw control for speech. *Journal of Speech, Language, and Hearing Research*, *45*, 66-79.

Nijland, L., et al. (2004). Speech motor coordination in Dutch-speaking children with DAS studied using EMMA. *Journal of Multilingual Communication Disorders, 2(1),* 50-60.

HYPERNASALITY: INTERRELATIONS OF ACOUSTIC PATTERNS OF SPEECH AND BRAIN IMAGING TECHNIQUES

Szabolcs Horváth[1], Mária Gósy[2]
[1] *Saint Roch Hospital,* [2] *Linguistics Institute, HAS, Budapest, Hungary*
horviki@nytud.hu

Introduction

The function of the velopharyngeal mechanism is critical for the control of oral-nasal balance during speech. Hypernasality is a voice disorder that can affect the whole of a speaker's speech production and also listener perception. Velopharyngeal disfunction either as the main or an attendant phenomenon of a disease, is of crucial importance, and results in voice quality alterations or changes the velopharyngeal port closure. Hypernasality may be induced by a variety of etiologies.

Methods and Results

The present study was designed to determine the possible interrelations between nasal resonance, the acoustic parameters of hypernasalized speech and organic deficits like traumatic brain injury, myopathia, bulbar myasthenia gravis or myotonia. 12 Hungarian-speaking children (ages between 5 and 14) and 12 Hungarian-speaking adults (aged between 40 and 65) were selected to participate in the experiment. All of them were registered at the Neurological Department of the Saint Roch Hospital (Budapest) having complained of nasality. Each speaker's problem was believed to relate to higher dysfunctions located somewhere in the brain. The subjects' speech (words, word combinations and a short spontaneous sample) was recorded, digitalized and analyzed acoustically (time and intensity structure, formants, nasal resonance, speech tempo, F0 values were analysed using CSL 4300B). In addition, clinical examinations and assessments of each patient took place (using electrophysiology, electromiography, and imaginary diagnostics).

The specific frequency range of the nasality and the harmonic components of the vowels showed significant differences between children and adults. The nasal frequency range was characteristic of the type of the organic brain disorder.

Discussion

Results highlight the specific interrelations between some acoustic parameters of hypernasalized speech and the underlying clinical data. Since the degree of hypernasality in speech production cannot be perceived objectively even by trained listeners, a range of diverse approaches to the phenomenon might enable us to identify the actual location of the dysfunction. Comparison of the acoustic-phonetic analysis and the clinical examinations seems to help distinguish central and peripheral organic brain disorders taking a patient's nasalized speech as the starting point.

References

McHenry, M.A. (1998). Velopharyngeal airway resistance disorders after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *79*, 545-549.

Hong-Shik, Ch., Yong-Jae, P., & Kwang-Moon, K. (2001). Devising an Objective Nasal Vibration Test for Nasal Resonatory Disorders. *Journal of Voice*, *15*, 220-230.

ANTICIPATORY LABIAL COARTICULATION IN FRENCH: ACOUSTIC AND ARTICULATORY PATTERNS IN DEAF AND NORMAL HEARING SUBJECTS

Johanna-Pascale Roy, Lucie Ménard
Laboratoire de phonétique, Université du Québec à Montréal, Canada
johannaproy@hotmail.com

Introduction

This work is a contribution to studies on anticipatory gestures in speech, comparing productions of deaf and normal-hearing subjects using articulatory and acoustic data. Previous studies on coarticulation produced by deaf subjects showed that, at the acoustic level, deaf speakers tend to show reduced coarticulation compared to hearing controls. Okalidou and Harris (1999) showed that this effect may vary as a function of consonantal or prosodic context. Moreover, it was observed that coarticulatory gestures are similar, in several cases, with coarticulatory behaviour of children, comparing these results with those of studies on speech development. It was hypothesized that, like children, deaf subjects would not have accumulated enough auditory information, leading them to lack a fine motor control development.

Methods and Results

Sentences including a /iCₙy/ sequence were pronounced by 5 normal-hearing adult subjects and 5 deaf subjects, age matched, with French as a first oral language. Each sentence was repeated ten times, in random order, at a normal speaking rate. The acoustic signal, as well as lip kinematics, have been recorded. Measurements of formant frequencies (especially F2) and lip trajectory, velocity and acceleration have been processed. Results show that, in spite of inter-individual variability, normal-hearing subjects tend to show a linear expansion of anticipatory rounding gesture as duration of consonantal interval increases. For some deaf subjects, anticipatory rounding gestures may begin at a fixed time before acoustic onset of the rounded vowel while some others produced more scattered data, even though all deaf subjects produced vowels that are acoustically comparable to those of normal hearing subjects.

Discussion

In the case of anticipatory rounding gestures in French, for /iCₙy/ sequences, children generally produce coarticulatory patterns that are similar to those of adults (Noiray et al., 2004). In the present study, anticipatory behaviours of deaf subjects are not comparable with children population. Our results are in line with studies suggesting that the organisation of speech gesture may not be the same for normal hearing and deaf subjects in many cases.

References

Noiray, A., Ménard, L., Cathiard, M.-A., Abry, C., & Savariaux, C. (2004). The development of anticipatory labial coarticulation in French: A pioneering study. *Proceedings of Interspeech 2004*, Jeju Island, S. Korea.

Okalidou, A. & Harris, K.S. (1999). A comparison of intergestural patterns in deaf and hearing adult speakers: Implication from an acoustic analysis of disyllables, *Journal of the Acoustical Society America*, *106(1)*, 394-410.

SPEECH MOTOR DEFICITS AFTER SEVERE TRAUMATIC BRAIN INJURY IN CHILDHOOD

Thomas F. Campbell[1,2], Christine Dollaghan[1], Heather Rusiewicz[1], Steven Small[3], Frederic Dick[4], Helen Wier[3]

[1]University of Pittsburgh, [2]Children's Hospital of Pittsburgh, [3]University of Chicago, USA

[4]University of London

Introduction

Little information exists on the speech production of children following severe traumatic brain injury (TBI). Segmental and suprasegmental errors may persist up to 12 months post-injury but the relationship between speech errors and the volume of damaged tissue in such children is unknown. We asked whether the total volume of discrete brain lesions was associated with an increased frequency of two types of speech errors that have been linked to motor deficits: speech sound distortions and errors of prosody and voice.

Methods and Results

Monolingual English-speaking children (*N*=57) were followed prospectively after severe TBI (Glasgow Coma Score< 8). Age at injury ranged from 0;01 to 10;6 (years;months). Fifteen-minute speech samples were recorded during 12 monthly sessions; data reported here are from the final session when ages ranged from 2;9 to 11;6. The average percentage of distortion errors (42.03) exceeded percentages of omission and substitution errors (28.63 and 29.35, respectively). The average number of prosody-voice errors per utterance ranged from 0.25-3.96 (M =1.10). The volume of discrete brain lesions identified from structural magnetic resonance images obtained near the time of the speech sample did not correlate significantly with distortion errors or with prosody-voice errors.

Discussion

Although segmental and suprasegmental findings suggest that the long-term speech outcomes of these children reflect underlying speech-motor deficits, the severity of such deficits is not predicted by total volume of discrete brain lesions. Analyses of the relationship between speech deficits and other structural indices of brain injury (e.g., total percentage of intact gray and white matter) are in progress.

References

Campbell, T.F. & Dollaghan, C.A. (1995). Speaking rate, articulatory speech, and linguistic processing in children and adolescents with severe traumatic brain injury. *Journal of Speech and Hearing Research*, *38*, 864-875.

Shriberg, L.D. (1993). Four new speech and prosody-voice measures for genetics research and other studies in developmental phonological disorders. *Journal of Speech and Hearing Research*, *36*, 105-140.

TESTING THE SENSORY FEEDBACK DEPENDENCE HYPOTHESIS IN PEOPLE WHO STUTTER

Aravind Kumar Namasivayam, Pascal van Lieshout
Oral Dynamics Laboratory, Department of Speech-Language Pathology
University of Toronto, Canada
a.namasivayam@utoronto.ca

Introduction

It has been suggested that people who stutter (PWS) either have problems in using kinaesthetic information or overly depended on sensory information for speech motor control (Van Lieshout et al., 2004). The present study examined feedback control in PWS by applying sensory perturbations during the production of simple speech tasks. It was hypothesized that if PWS depend more strongly on feedback control during speech, they should show an increase in coordination variability during feedback perturbation conditions.

Methods and Results

Five adult PWS and five matched controls (20 – 40 years) participated in this experiment. All subjects repeated nonsense syllables at two different rates (normal and fast), either independently or in a switching task under different combinations of sensory perturbations (auditory - masking noise; proprioceptive - tendon vibration; with or without a bite-block) while their speech movements were tracked using the AG100 EMMA system. Contrary to our expectations, PWS were not found to be more variable than controls when faced with different forms of sensory perturbation, either isolated or combined. In fact, for the bite-block condition PWS showed a decrease in variability compared to jaw-free speech whereas control speakers showed the opposite trend.

Discussion

The data does not provide direct support for either the feedback dependency or the kinaesthetic deficiency hypotheses mentioned above. In the latter case, we should have found an increase in variability for auditory masking in bite-block conditions, where the potential role of kinaesthetic feedback would be stronger. One possible explanation for these findings is that when confronted with distortions in the feedback channels and a reduction in the degrees of freedom (bite-block), PWS revert to a stereotypical coordinative pattern, as shown particularly in their very consistent phasing of upper and lower lip movements. Further details of this study will be presented at the conference.

References

Van Lieshout, P.H.H.M., Hulstijn, W., & Peters, H.F.M. (2004). Searching for the weak link in the speech production chain of people who stutter: A motor skill approach. In: B. Maassen, R. Kent, H. Peters, P. Van Lieshout, & W. Hulstijn (Eds.) *Speech Motor Control in Normal and Disordered Speech*, 313-356. Oxford: Oxford University Press.

INVESTIGATING THE NEURAL BASIS OF STUTTERING USING TRANSCRANIAL MAGNETIC STIMULATION

Justine Goozée[1], Bruce Murdoch[1], David Lloyd[2], Richard Carson[2], Stephen Riek[2], Nick O'Dwyer[3], Mark Onslow[4], Ann Packman[4], Carly Bartle[1] & Linda Goozée[1]
[1]School of Health and Rehabilitation Sciences & [2]School of Human Movement Studies , The University of Queensland, [3]School of Exercise and Sport Science & [4]Australian Stuttering Research Centre, The University of Sydney, Australia
j.goozee@uq.edu.au

Introduction

Transcranial magnetic stimulation (TMS) provides a means of examining the excitability and integrity of the cortical regions and corticobulbar tracts controlling the speech musculature. As such, TMS has the potential to speak to theories regarding the neural basis of stuttering. The technique involves stimulating cortical neurons through transient magnetic fields that are generated by a flat wire coil held against an individual's scalp. When TMS is delivered to the motor cortex, the neural pathways leading to various voluntary muscles can be activated; with the resultant muscle contractions recorded as motor evoked potentials (MEPs) using electromyography (EMG). Only a limited number of studies have used TMS to investigate neural activation of the tongue, with optimal stimulation parameters having yet to be determined. The aim of the current study was to determine the optimal TMS coil orientation for stimulating the tongue as a precursor to our planned program of TMS research with adults who stutter.

Methods and Results

Seven non-neurologically impaired, right-handed adults (mean age: 44.30 years, SD 13.91; 4 males) participated. A figure-of-eight TMS coil (Magstim 200[2]) was held against the left side of the head, with the location of the tongue motor cortex and the active motor threshold (i.e., lowest level of stimulation required to induce a response in the tongue) determined. At this site, five TMS pulses were delivered at eight different coil handle orientations (separated by 45 degrees; see figure) at a stimulation level of 120% of active motor threshold. A constant coil position on the head was maintained by means of a Stealthstation, TREON™. MEPs, recorded using a bipolar surface electrode attached to the tongue, revealed greatest amplitudes at angles 315°, 0°, 45° and 90° (see figure), with 90° exhibiting the most consistent amplitudes.

Discussion

The data suggests that the TMS coil handle should be directed at angles ranging from 315° to 90° to elicit maximal and consistent MEPs in the tongue. Variability between subjects and the small subject numbers utilised in the present study preclude a particular optimal angle from being identified at this time.

References

Sommer, M., Wischer, S., Tergau, F., & Paulus, W. (2003). Normal intracortical excitability in developmental stuttering. *Movement Disorders*, *18(7)*, 826-830.

CLUTTERING BETWEEN HYPO- AND HYPERARTICULATION

Mariam Hartinger
Centre for General Linguistics, Typology and Universals Research (ZAS), Berlin, Germany
hartinger@zas.gwz-berlin.de

Introduction

Although clutterers' speech is described as rapid and hasty, adult clutterers are sometimes able to speak intelligible, depending on the relevant situation. This improvement of fluency due to concentration is an important criterion for distinguishing cluttering from stuttering. However, it is unclear why clutterers cannot always speak slowly and intelligibly. Causes from rather diverse fields are discussed in the literature, such as neurological causes as well as difficulties in the conceptualisation or coordination of speech. The aim of the present study was to investigate articulatory strategies of clutterers and a control group of normal speakers. Due to the intra-individual varying pathology, a more variable speech production was expected for clutterers. Furthermore, in terms of the presumed higher speech rate of clutterers, shorter articulatory durations and smaller amplitudes were hypothesised.

Methods and Results

The kinematic data of three adult clutterers and three normal speakers, ranging in age from 21 to 36, were recorded by means of electromagnetic midsagittal articulography (EMMA). All speakers were native speakers of German. The speech material consisted of foreign words since clutterers are known to have most difficulties with these. The words consisted of a minimum of 5 and a maximum of 8 syllables and were embedded in a carrier sentence. The subjects were instructed to speak as fast and as intelligibly as possible. The results of the study show that articulatory gestures of clutterers are- against expectations- not always shorter and smaller than those of normal speakers. On the one hand there were data that could not be analysed due to gestural reduction, strong coarticulation, and target undershoot. On the other hand- despite shorter articulatory and acoustic durations- two out of three clutterers showed larger amplitudes than normal speakers. The coefficient of variation revealed a higher variability for clutterers than for normal speakers for both spatial and temporal measures. In particular, the spatial data showed an outstanding distribution towards large amplitudes.

Discussion

The findings of the present study confirmed a remarkable strong intra-individual variability of clutterers. The large articulatory movements were interpreted with respect to a tendency to hyperspeech. The data that could not be analysed were assumed to involve hypoarticulation in that speech rate was too high and articulatory precision was too low. In terms of the H&H theory speakers normally "… develop a 'feel' for the 'survival value' of phonetic forms …" (Lindblom 1990, p. 405). The study proved that clutterers very often produce hypospeech. One of the reasons could be that the monitoring process during speech production does not work sufficiently. For speech therapy is it advisable to practise hyperarticulation in order to improve the intelligibility. This strategy seems easier to realise for clutterers than the task to reduce speech rate.

Reference

Lindblom, B. (1990). Explaining phonetic variation: A sketch of the H&H theory. In: W. J. Hardcastle & A. Marchal (Ed.) *Speech Production and Speech Modelling*, 403-439. Dordrecht: Kluwer.

COARTICULATION AND STUTTERING IN FLUENT SYLLABLES UNDER CONTRASTIVE FOCUS

Claudio Zmarich, Massimiliano Marchiori
Istituto di Scienze e Tecnologie della Cognizione-C.N.R., Padova, Italy
zmarich@pd.istc.cnr.it

Introduction

A long-held view in the research field on stuttering explains it as a difficulty in realizing the appropriate transition between the consonantal onset and the vocalic nucleus of the syllable (see Subramanian, et al. 2003). Other researches points to prosodic influences on the speech of stutterers (see Bergmann, 1986), which cause, for instance, a stuttering increase in the words under contrastive focus. This work analyzes the prosodic influences on the coarticulation of stressed and unstressed CV syllables under informative *focus* or contrastive *focus*, with the aim to find whether stutterers perform the anticipatory coarticulatory influence of V over C in a significantly different way from nonstutterers in the contrastively accented syllables, reported to be more effortful and resistant to coarticulatory processes than the unstressed syllables and the stressed, but not contrastively accented, syllables.

Methods and Results

Four adult stutterers and four nonstutterers read aloud declarative sentences with normal (Subject-Verb) and inverted word order (Verb-Subject), as an answer to appropriate questions. The verb was kept constant ("viene"), whereas the subject, a three-syllabic pseudoname ("dadada" or "dididi"), was systematically varied for lexical stress. Each of the two words could be focussed, and the focus had scope (i) on the whole sentence (informative broad focus), (ii) on the first word (narrow initial contrastive focus), (iii) on the second word (narrow final contrastive focus). Acoustic analysis of the fluent productions show that stutterers assign the main prominence to the initial name even when it is not under focus and that they realize the F0 peak for the word in narrow focus earlier than nonstutterers do. As to coarticulation, stutterers were found to have a greater slope coefficient of the regression line for $F2_C$ e $F2_V$ values (Sussman, et al., 1999).

Discussion

The results about coarticulation processes in stutterers indicate faster and wider tongue movements from consonant target to vocalic targets with respect to nonstutterers, i.e less coarticulation. Maybe some subtle dysfunctions of the respiratory, laryngeal, supralaryngeal systems and of their coordination, as found by physiological research on stuttering, could be triggered by the variability of the focal accent position in the sentence and by the complexity of its (co)articulatory realization, especially at the utterance initial position.

References

Bergmann, G. (1986). Studies in stuttering as a prosodic disturbance, *Journal of Speech and Hearing Research, 29*, 290-300.

Subramanian, A., Yairi, E., & Amir, O. (2003). Second formant transitions in the fluent speech of persistent and recovered preschool children who stutter, *Journal of Communication Disorders, 36,* 59-75.

Sussman, M., Duder, C., Dalston, E., & Cacciatore, A., (1999). An acoustic analysis of the Development of CV Coarticulation: A case study, *Journal of Speech, Language, and Hearing Research*, *42,* 1080-1096.

CHRONOMETRIC ANALYSIS OF VERBAL RESPONDING IN PEOPLE WHO STUTTER: A DEFICIT IN MUSCLE COMMAND PREPARATION?

Neville Hennessey[1], Charn Nang[2] , Esther Dourado[1], Janet Beilby[1]
[1]Curtin University of Technology, [2]The University of Western Australia, Australia
N.Hennessey@curtin.edu.au

Introduction

People who stutter (PWS) typically show longer verbal reaction times (RTs) compared to fluent age-matched controls, and this may be connected with the underlying cause of their dysfluent speech. However, longer RTs could reflect inefficient linguistic planning or deficits in speech motor control (Peters, Hulstijn, et al., 2000). The present research compared adult PWS and age-matched controls on RT tasks designed to probe different levels of speech production to explore where the deficit might lie. To probe word form encoding, we examined the effect of phonologically and semantically related auditory distracters on picture naming RT. To probe phonetic encoding, we compared word and non-word verbal responses in a simple and choice RT task. To probe muscle command preparation, we used an emotional stroop paradigm to investigate the impact of implicit emotional reactions to threat words on colour naming RT, while responding at either a fast or normal rate of production.

Methods and Results

In Study 1, PWS (n = 18) named pictures more slowly (M = 885 ms) than controls (n = 18, M = 808 ms). There was no group difference in the facilitation of RT from hearing phonologically related auditory distracter words at the time of picture presentation. Further, there was no difference between PWS and controls in inhibition of picture naming RT from hearing semantically related auditory distracter words. PWS also demonstrated longer choice verbal RTs (683 vs. 615 ms), but the difference between word and non-word responses was the same for both groups, and there was no group difference in simple RT.

In Study 2, PWS (n = 13) named the colour of visually presented negative emotion words (e.g., *failure*) more slowly than neutral words. This effect was not seen in controls (n = 13). The emotionality effect was not present for PWS in simple verbal RTs or when responding manually. PWS did not differ from controls in state or trait anxiety. RTs were significantly faster for the fast compared to normal rate of production for controls, but not for PWS.

Discussion

In Study 1 PWS were overall slower to respond, yet we observed no group difference in phonological priming, semantic priming or the effect of lexicality on RT. The findings suggest no underlying deficit in word form or phonetic encoding in PWS. In Study 2, an emotionality effect on colour naming was observed for PWS but not controls, suggesting an enhanced tendency in PWS for implicit emotional reactions to threat words to interact with speech motor control. PWS also appear less effective at rate control. The findings across both studies are consistent with deficient muscle command preparation in PWS, possibly reflecting a limitation in merging the segmental and suprasegmental characteristics of spoken language.

References

Peters, H., Hulstijn, W., & van Lieshout, P. (2000). Recent developments in speech motor research into stuttering. *Folio Phoniatrica et Logopaedica*, *52*, 103-116.

THE EFFECTS OF A SINGLE SELF-GENERATED SYLLABIC PRIME ON STUTTERING FREQUENCY

Monica Strauss Hough[1], Gregory Snyder[2]
[1]*East Carolina University, Communication Sciences & Disorders, Greenville, NC,* [2]*University of Mississippi, Department of Communicative Disorders, University, MS, USA*
HoughM@ecu.edu

Introduction

While stuttering behaviors can be temporarily ameliorated, it remains unclear how or why fluency is enhanced in those who stutter. Although research suggests that fluency can be enhanced in those who stutter via endogenous (self-generated) and exogenous (externally-generated) methodologies, it is unknown if there is a common invariant found in these methodologies that is necessary and sufficient to stimulate fluency enhancement. As previous research indicates that stuttering moments represent a failure to initiate a speech gesture, it is suggested that a common invariant within endogenous and exogenous fluency enhancement is the cognitive initiation of the speech gesture. The purpose of this study is to test the effects of (speech-related) cognitive initiation (approximated by single self-generated syllabic prime) on stuttering frequency.

Methods and Results

Speech-related cognitive initiation was approximated by a single self-generated syllabic prime. Primes took the form of forearm movement, tongue clicks, and silent oral opening frames; primes were produced to fluidly initiate production of initial speech gesture of each breath group. Participants used this self-generated technique on all initial speech gestures of every breath group. Reading passages used in this study have been used in previous peer reviewed research.

Study results revealed a 42%, 47%, and 53% reductions of stuttered syllables occurring in the initiatory hand movement, tongue-click, and oral opening frame conditions, respectively. An ANOVA conducted on these data revealed a significant main effect of self-generated syllabic priming. Post hoc orthogonal single df comparisons revealed a significant difference between the control and all three syllabic priming conditions; however, no significant difference in stuttering frequency was found between hand movement when compared to tongue click and oral opening frame conditions.

Discussion

Self-generated cognitive initiation strategies appear to be less efficient at enhancing fluent speech than other methods of stuttering reduction, such as those invoking speech feedback. Thus, it appears that self-generated cognitive initiation does not serve as the common invariant responsible for enhanced fluency in stuttering.

References

Dayalu, V., Saltuklaroglu, T., Kalinowski, J., Stuart, A., & Rastatter, M.P. (2001) Producing the vowel /a/ prior to speaking inhibits stuttering in adults in the English language. *Neuroscience Letters*, *22*, 111-115.

Kalinowski, J., Dayalu, V., Stuart, A., Rastatter, M.P., & Rami, M.K. (2000). Stutter-free and stutter-filled speech signals and their role in stuttering amelioration for English speaking adults. *Neuroscience Letters*, *27*, 115-118.

Peters, H.F.M. (2000). Recent developments in the speech motor research into stuttering. *Folia Phoniatrica et Logopaedica*, *52*, 103-119.

THE EFFECTS OF A SINGLE SILENT INITIATING SPEECH GESTURE ON STUTTERING FREQUENCY

Gregory Snyder[1], Monica Strauss Hough[2]
[1]*University of Mississippi, Department of Communicative Disorders, University, MS,*
[2]*East Carolina University, Communication Sciences & Disorders, Greenville, NC, USA*
GSnyder@olemiss.edu

Introduction

While stuttering behaviors can be temporarily ameliorated, it remains unclear how/why fluency is enhanced in those who stutter. Previous research investigating a common invariant for fluency enhancement measured effects of cognitive initiation on stuttering frequency; it was less efficient than fluency derived from a second speech signal (SSS). Exposure to an initiating speech gesture (embedded in SSS) may be a common invariant found with fluency enhancement. Although research shows fluency enhancing effects of SSS, it is unknown if enhancement via initiating speech gestures results from phonation exposure or inherent cognitive initiation associated with gesture production (un-phonated) itself. This study tested effects of silent initiating speech gestures on stuttering frequency.

Methods and Results

The study employed one control and four experimental speaking conditions: self-generated initiating silent speech gesture without visual feedback (SGISG), self-generated initiating silent speech gesture with visual feedback (SGISG w/VF), externally-generated initiating silent speech gesture with visual feedback EGISG w/VF), and self-generated initiating silent speech gesture simultaneously co-occurring with an externally-generated initiating silent speech gesture providing visual feedback (SGISG + EGISG w/ VF). A head-mounted video camera (Audi-See) provided visual feedback. Participants used an initiating speech gesture on all initial speech gestures of every breath group.

Study results revealed 55%, 77%, 73%, and 76% reductions of stuttered syllables occurred in the production of an SGISG, SGISG w/ VF, EGISG w/ VF, and SGISG +EGISG w/ VF, respectively. A significant main effect of initiating silent speech gesture was found. Post hoc comparisons revealed a significant difference between control and experimental speaking conditions. Comparisons contrasting conditions employing (and not employing) visual feedback revealed a trend toward significant reductions in stuttering frequency.

Discussion

Results indicate that perception of a fluency enhancing stimulus (not self-generation) is the most effective method of reducing stuttering frequency. This finding supports the notion that a dual-premotor-system, or mirror neurons, may be influence fluency enhancement.

References

Armson, J. & Kalinowski, J. (1994). Interpreting results of the fluent speech paradigm in stuttering research: difficulties in separating cause from effect. *Journal of Speech, Language, and Hearing Research*, *37*, 69-82.

Fox, P.T., Ingham, R.J., Ingham, J.C., Zamarripa, F., Xiong, J.H., & Lancaster, J.L. (2000). Brain correlates of stuttering and syllable production. *Brain*, *123*, 1985-2004.

Salmelin, R., Schnitzler, A., Schmitz, F., & Freund, H.J. (2000). Single word reading in developmental stutterers and fluent speakers. *Brain*, *123*, 1184-1202.

EXPLORING THE RELATIONSHIP BETWEEN EPILEPSY AND STUTTERING: AN EEG INVESTIGATION

Libby Smith[1,2], Sheena Reilly[1,2,3], Bronwyn Parry-Fielder[2], Vicki Anderson[1,2], Sue Block[3], Mark MacKay[3], Kerry Ttofari[1,2], Carly Veness[1,2], Sue Watson[2]

[1] Murdoch Children's Research Institute, [2]Speech Pathology/Psychology Departments, Royal Children's Hospital, [3]School of Human Communication Sciences, La Trobe University, Melbourne, Australia

sheena.reilly@mcri.edu.au

Introduction

An increased number of EEG (electroencephalogram) abnormalities have been reported in individuals who stutter, but these are not well described. Sleep is known to activate EEG abnormalities in two well-known childhood epilepsy conditions, Landau-Kleffner syndrome (LKS) and Benign Focal Epilepsy of Childhood (BFEC). Both conditions are associated with speech and language difficulties, and with stuttering in a small number of cases. In both LKS and BFEC, children's speech and language symptoms have been shown to improve through the use of medication. Hence it is important to know about the prevalence of sleep EEG abnormalities in developmental stuttering as anecdotal evidence suggests that appropriate medication may reduce stuttering severity. This study aimed to determine if there is a group of children who stutter who have an epileptic tendency as demonstrated by an abnormal EEG.

Methods and Results

Participants were community-ascertained cases of children who stutter and controls aged 5;0 to 10;0 years with no frank neuropathology. We undertook a battery of speech, language and fluency assessments and collected sleep and awake EEG data. EEG recordings were classified by a neurologist as normal, abnormal or epileptiform. Of the 16 cases, 8 (50%) had an abnormal EEG as compared with 2 (25%) controls. Of these, 4 cases (25%) and 1 control (12.5%) were epileptiform, suggesting an association between epileptiform EEGs and developmental stuttering.

A single participant has undergone a trial of medication following identification of epileptiform EEG, with subsequent improved fluency. These results will also be presented.

Discussion

Children who stutter are at increased risk of abnormal EEG. This raises the question of whether EEG screening is indicated as standard practice in the assessment of children with persistent stuttering, particularly given the initially positive impact of anticonvulsant medication on stuttering severity. Future investigation into the relationship between abnormal EEG and stuttering should involve a formal medication trial to evaluate the potential of anti epileptic medications to reduce stuttering.

References

Khedr, E., El-Nasser, W.A., Abdel Haleem, E.K., & Bakr, M.S. (2000). Evoked potentials and electroencephalography in stuttering. *Folia Phoniatrica et Logopaedica*, *52(4),* 178-86.

Deonna, T.W., Roulet, E., Fontan, D., & Marcoz, J.P. (1993). Speech and oromotor deficits of epileptic origin in BPERS. *Neuropediatrics*, *24(2)*, 83-7.

Tutuncuoglu, S., Serdaroglu, G., & Kadioglu, B. (2002). Landau-Kleffner syndrome beginning with stuttering: case report. *Journal of Child Neurology*, *17(10)*, 785-8.

DIFFERENTIAL FLUENCY IN BILINGUALS WHO STUTTER: QUESTIONING NEURO-COGNITIVE ASSUMPTIONS

Victor J. Boucher, Mounir Zaïdi
Université de Montréal, Canada
victor.boucher@umontreal.ca

Introduction

Differential stuttering in balanced bilinguals offers a particular challenge to assumptions of a neuro-cognitive basis to stuttering. What is of interest in these cases is that differential fluency in the *same* speaker using two languages is not explained by assumptions of dysfunctional auditory feedback, or defective cognitive processing of speech communication. Instead, one should consider the parallels between stuttering and spasmodic dysphonia (Ludlow & Louks, 2003), where varying demands on glottal-aperture control influences blocking. This report presents cases of Arabic-French bilinguals with the view that differential stuttering in these individuals can be predicted by the degree to which voicing is controlled directly by glottal actions (as in Arabic), or indirectly by way of the passive effects of intra-oral pressure (Boucher & Lamontagne, 2001). This principle can also account for the absence of stuttering, as reported by these individuals, during prayer recitations.

Methods and Results

Three compound Arabic-French bilinguals with a history of stuttering since childhood (but who received no therapy) were videotaped during an interview on five conversation themes. On each theme, the interviewer changed language (though "switching" was avoided). Two native speakers transcribed the videotapes and calculated blocking rates (reliability of 97%). Blocking frequency was higher for Arabic than French across themes and speakers.

These observations were complemented by comparisons using automated acoustic measures of voice breaks in Arabic and French normal speech and prayer recitation. For native speakers of each language, Arabic presents much higher percentages of voice breaks than French, and for both languages speech has higher percentages than prayer recitatiion.

Discussion

Boucher and Lamontagne (2001) showed that speakers make use of an indirect control of voicing when producing oral constrictions in speech. In this indirect mode, pressure rises affect transglottal flow and modulates vocal-fold vibration without modifying glottal opening or tonus. A direct control of voicing during oral openings creates instability in vocal-fold tension, aggravating the likelihood of stuttering. This principle explains a number of fluency-enhancing effects (as in prayer). Moreover, such effects are compatible with a view that stuttering involves a deficient inhibition of laryngeal reactivity, which is further supported by functional similarities with focal dystonias like spasmodic dysphonia.

References

Ludlow, C.L. & Loucks, T. (2003). Stuttering: a dynamic motor control disorder. *Journal of Fluency Disorders*, *28*, 273-295.

Boucher, V.J. & Lamontagne, M. (2001). Effects of speaking rate on the control of vocal fold vibration : Clinical implications of active and passive aspects of devoicing. *Journal of Speech, Language, and Hearing Research*, *44*, 1005-1014.

PHYSIOLOGIC AND BEHAVIORAL CLASSIFICATION OF DELAYED SPEECH

Christopher A. Moore[1], Thomas F. Campbell[2], Lawrence D. Shriberg[3], Jordan R. Green[4], Lakshmi Venkatesh[1], Jennell Vick[1], Heather Leavy Rusiewicz[2]
[1]University of Washington, [2]University of Pittsburgh, [3]University of Wisconsin - Madison
[4]University of Nebraska - Lincoln, USA
camoore@u.washington.edu

Introduction

Translating quantitative description of speech into clinical application has been impeded by several challenges: differences among observational domains or levels of analysis, inferring population characteristics from limited samples, and lack of concurrence among multiple methods of clinical classification. Stage models of spoken language production predict isolable stages of disruption (e.g., phonologic encoding, motor programming, coordin-ative organization, execution) presumably associated with differences in the surface characteristics of the output (aberrant movement, phonetic/phonological errors), which ideally could be realized as distinct classifications of disorder (dysarthria, apraxia, phonologic disorders). Such distinctions are rarely observed, however; interactions among language formulation, speech programming, and movement are easily demonstrated, and disruptions of speech development remain poorly differentiated. This investigation addressed these challenges in a large sample of preschool children with speech delay of unknown origin. Physiologic, acoustic, and behavioral observations were evaluated to obtain emergent, rather than pre-defined, classifications using statistical clustering, and to characterize speech performance across these domains.

Methods and Results

Participants were 186 children, aged 3-5 years, 83 of whom had typical speech; 103 had idiopathic speech delay. Children were tested on behavioral measures (e.g., Goldman-Fristoe, CELF, challenging words, lexical stress, phonological awareness) and speech performance tasks (e.g., nonword and sentence repetition, diadochokinesis, iambic, trochaic, and spondee repetitions). Analyses crossed domains, including detailed phonetic/phonologic analysis (Shriberg et al., 1997; 2001), physiologic (movement analysis of jaw, lips, ribcage, abdomen), and acoustic (f_0, speech amplitude, spectrographic features) measures. These data were subjected to cluster analysis to identify emergent subgroups.

Discussion

Preliminary evaluation of this large data set confirms previous observations of the interaction of speech and language processes, the decrease in movement variability associated with development, and the appearance of subclinical aberrations (i.e., below the perceptual threshold for disorder) in the typical-sounding speech of children with speech delay. The occurrence of clusters represents differential speaker categories and potentially, diagnostic categories.

References

Moore, C.A. (2004). Physiologic development of speech production. In: B. Maassen, H.F.M. Peters, P.H.H.M. Lieshout, & W. Hulstijn (Eds.). *Speech Motor Control in Normal and Disordered Speech*, 191-209. Oxford: Oxford University Press.

Shriberg, L.D., Allen, C.T., McSweeny, J.L., & Wilson, D.L. (2001). PEPPER: Programs to examine phonetic and phonologic evaluation records [Computer software]. Waisman Center, University of Wisconsin-Madison.

Shriberg, L.D., et al. (1997). The Speech Disorders Classification System: Extensions and lifespan reference data. *Journal of Speech, Language and Hearing Research*, *40*, 723-740.

DYNAMIC INTERACTION OF MOTOR AND LANGUAGE FACTORS IN SPEECH PRODUCTION

Lisa Goffman and Anne Smith
Speech, Language, & Hearing Sciences, Purdue University, USA
goffman@purdue.edu

Short Overview

One goal of our research program is to explicate how language production processes interact with motor control mechanisms. We have previously presented evidence that linguistic and motor variables interact in complex ways over the course of development. Substantial progress has been made in specifying adult models of speech production (Levelt, Roelofs, et al., 1999), though little attention has focused on either developmental or on implementation factors. A prominent view is that the majority of the processing occurs prior to speech motor implementation. We suggest that multiple levels of processing also operate at the implementation level (Smith & Goffman, 2004). Over the past several years we have been working to provide more detail about how these interactions occur in normal and disordered development.

First, we will report on broad sentential effects on implementation processes. Previously, we have shown that, for children and adults, coarticulatory lip rounding movements transcend the syllable and the word and affect an entire sentence. In addition, changes in syntactic complexity have been observed to influence multiple aspects of speech motor output. Finally, recent work has demonstrated that lexical familiarity in utterance final position influences the variability of movement output in an utterance initial noun. Overall, these results not only illustrate the breadth of production units in movement output, but also have implications for understanding how speech production units emerge developmentally.

Second, we focus on the influence of lexical knowledge on speech motor implementation. We have found that when a nonce phonetic string is given referential status, it is produced with decreased movement variability. Further, phonotactic frequency and neighborhood density have complex effects on output mechanisms.

Finally, we will report on prosodic findings. Prosodic structure is particularly important to consider, since it is thought to occur at the interface between phonology and syntax. We have argued that a more general capacity to produce basic movement patterns interacts with the acquisition of prosodic structure. In this line of research, we manipulate prosodic structure in linguistically meaningful contexts (e.g., within and across word boundaries; in mono- vs. multi-morphemic contexts) as well as in conditions in which linguistic content is stripped away (e.g., non-words; manual tapping tasks). We report on how movement is reorganized as a function of suprasegmental linguistic processes.

References

Levelt, W.J.M., Roelofs, A., & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*, 1-75.

Smith, A. & Goffman, L. (2004). Interaction of motor and language factors in the development of speech production. In B. Maasen, R. Kent, H. Peters, P. van Lieshout, & W. Hulstijn (Eds.) *Speech motor control in normal and disordered speech*, 225-252. Oxford: Oxford University Press.

EMERGENCE OF ROUNDING ANTICIPATORY CONTROL IN FRENCH

Aude Noiray [1], Lucie Ménard [2], Marie-Agnès Cathiard [1],
Christophe Savariaux [1], Christian Abry [1],
[1]*Institut de la Communication Parlée, Université Stendhal-INPG, Grenoble, France,*
[2]*Département de linguistique et de didactique des langues, Université du Québec à Montréal, Montréal (Québec), Canada*
noiray@icp.inpg.fr; menard.lucie@uqam.ca

Introduction

In speech, coarticulation is a fundamental mechanism allowing the fluent and dynamic production of upcoming speech targets. In adults, this coarticulation process has been largely described with a particular interest on anticipatory coarticulation modelling (*i.e. Look Ahead*, *Time-locked*, *Hybrid* model for the prediction of articulatory gestures timing in English; and *Movement Expansion Model* for French). When studying anticipatory coarticulation in a developmental point of view, we find that very few articulatory studies have been dedicated to the acquisition of speech segment control abilities, partly because of methodological constraints involved in studying young children.

According to the literature, coarticulation would progressively reach the maturity of adult speech with the achievement of neuromuscular control of articulators around 12 years old or even later as concern the vocal tract.

Methods

In order to track the development of vocalic anticipatory behaviour, we ran an experimental study with 7 French children aged from 3.5 to 8 years old with a follow up for the 4 youngest children and two adult females taken as reference. A lip area tracking system enabled us to analyse the extent of the rounding movement in [iCny] items (with C corresponding to a varying number of consonants from 0 to 3) presented as puppet names in sentences like “Le toutou Iku est rouge The dog Iku is red”.

Results and Discussion

The results show that the motor control required for vocalic anticipatory gestures is likely to reach adult like pattern as soon as 3.5 years old in our study. Indeed, we found the same regular temporal pattern of anticipatory coarticulation as previously evidenced in French adults.

Therefore, the 3 to 5 years old period seems crucial for the acquisition of anticipatory control in the timing of vocalic gestures. These results suggest that in a language like French for which rounding contrast seems essential, this control can be settled quite early.

References

Kent, R.D. (1976). Anatomical and neuromuscular maturation of the speech mechanism: evidence from acoustic studies. *Journal of Speech and Hearing Research*, *19*, 421-447.

Abry, C. & Lallouache, T. (1995). Le *MEM*: Un modèle d’anticipation paramétrable par locuteur. Données sur l’arrondissement en français. *Bulletin de la Communication Parlée*, *3*, 85-99.

BRAIN IMAGING RESEARCH IN STUTTERING

Luc De Nil[1,2,3] and Deryk Beal[1,3]
[1]Department of Speech-Language Pathology, University of Toronto , [2]Toronto Western Research Institute, [3]Hospital for Sick Children; Toronto, Canada.
luc.denil@utoronto.ca

Short overview

Brain imaging tools have allowed researcher to lift a few hitherto inaccessible corners of developmental stuttering. Although the results of these studies have not always been in agreement, in part due to differences in the experimental tasks used, some general trends can be seen: (1) a general overactivation of cortical and subcortical sensorimotor systems involved in natural speech production; (2) increased right hemisphere and/or bilateral activation; (3) decreased activation in left auditory cortex; and (4) atypical functional or effective neural connections between brain regions. Furthermore, some recent studies have reported structural brain anomalies in stuttering adults.

Functional activation differences between stuttering and nonstuttering speakers can be influenced by modifying experimental tasks that manipulate underlying cognitive processes (e.g., word repetition vs. word generation), overt speech articulation (e.g. silent word reading, covert articulation or overt speech production) and/or stuttering severity (e.g., choral reading or speech treatment). Furthermore, it appears that increased fluency may result in a greater normalization of observed activation patterns. The observation that neural activation differences between stuttering and nonstuttering speakers appear to diminish when motor-related activation is subtracted out, suggests that differences may be specific to motor planning and execution rather than higher level cognitive (e.g., psycholinguistic) formulation processes.

A critical issue that needs to be resolved is whether functional differences observed in adults are reactive to the presence of stuttering or, in stead, reflect developmental or inherent differences in brain organization. One way to approach this question is to investigate functional differences in young children. Unfortunately, while MEG may hold some promise, fMRI and PET are not (yet) suitable for the study of very young (e.g. preschool) children who stutter. Studies of school-age children have started, but these studies probably will not result in conclusive answers to the reactive vs. innate debate because of extensive experiences with stuttering even at this young age. One could also approach this question by investigating the extent to which voluntary stuttering-like behaviour may result in overactivation patterns similar to those seen in stuttering. We will report on the findings of one of our studies addressing this issue. In addition, we will review the existing imaging literature as it relates to stuttering and discuss how the reported findings can be interpreted within the context of functional imaging studies of normal language and speech processes. Specifically, the extent to which decreased activation in auditory cortex in stuttering may be related to auditory inhibition will be explored.

References

De Nil, L. (2004). Recent developments in brain imaging research in stuttering. In: B. Maassen, H.F.M. Peters, P.H.H.M. Lieshout, & W. Hulstijn (Eds.) *Speech Motor Control in Normal and Disordered Speech*,113-137. Oxford: Oxford University Press.

Brown, S., et al. (2005). Stuttered and fluent speech production: An ALE meta-analysis of functional neuroimaging studies. *Human Brain Mapping*, *25(1)*, 105-117.

VARIABILITY IN ORAL MOTOR CONTROL: WHERE DOES IT COME FROM AND WHAT DOES IT MEAN?

Pascal van Lieshout
University of Toronto, Speech-Language Pathology, Oral Dynamics Lab; Toronto Rehabilitation Institute; Institute of Biomaterials and Biomedical Engineering, Canada
p.vanlieshout@utoronto.ca

Overview

Variability in oral motor control has been an important topic in the literature for many years, dominated by the traditional view in which motor output has been interpreted as a mixture of an invariant control signal (e.g., motor command) contaminated by a degree of random variation, originating somewhere along the pathway from the central nervous system where the command was generated to the peripheral structures responsible for its execution. In line with this interpretation, variation in motor output is often labelled neuromotor noise and regarded as a nuisance that interferes with a smooth and accurate implementation of the original mental representation of the intended action. In patients with oral motor disorders, this line of reasoning is extended towards the idea of "more of the same problem", that is, due to disease or damage the amount of neuromotor noise increases, making it harder to produce a stable output. Thus, a natural consequence of this approach would be to identify ways in how a (normal) control system can attenuate neuromotor noise, for example, by increasing the stiffness of an effector system (Van Gemmert & Van Galen, 1997).

More recently, the strictly negative role attributed to variation in motor output and more specifically, the assumption that variability can be equated with randomness has been questioned in a series of limb control studies based on concepts and tools of Dynamical Systems Theory or DST (see Riley & Turvey, 2002). In addition, their authors emphasized the limitation of traditional measures of variability (e.g., standard deviations) in revealing structural aspects of the variability in motor performance. A robust finding of these studies indicates that contrary to the assumptions mentioned above, a more variable output (i.e., higher SD) is not by definition a more random output. In fact, increases in randomness were found to coincide with an optimization of information transfer, suggesting that higher noise levels reflect an increase in degrees of freedom to optimize the motor system's adaptability (Slifkin & Newell, 1999).

In this presentation, both traditional and DST based concepts on variability and noise will be explored in more detail using examples of oral kinematic data from both normal and disordered populations. In doing so, it will also confront the challenging question if (and how) it might be possible to uniquely identify the potential sources of movement variability and their relevance for oral motor control.

References

Riley, M.A. & Turvey, M.T. (2002). Variability of determinism in motor behavior. *Journal of Motor Behaviour*, *34*, 99-125.

Slifkin, A. & Newell, K.M. (1999). Noise, information transmission, and force variability. *Journal of Experimental Psychology-Human Perception and Performance*, *25*, 837-851

Van Gemmert, A.W.A., Van Galen, G.P., & van Gemmert, A.W.A. (1997). Stress, Neuromotor Noise, and Human Performance: A Theoretical Perspective. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 1299-1313

THE LESION-COMPENSATION THEORY OF STUTTERING: A FMRI STUDY

Katrin Neumann[1], Christian A. Kell[2], Harald A. Euler[3], Alexander Wolff von Gudenberg[4], Claudia Posenenske[1,5], Anne-Lise Giraud

[1]Clinic for Phoniatry and Pediatric Audiology and [2]Brain Imaging Center, Clinic for Neurology, University of Frankfurt/Main, Germany [3]Department of Psychology, University of Kassel, Germany, [4]Institut der Kasseler Stottertherapie, Bad Emstal, Germany, [5]Laboratoire de Neurosciences Cognitives, Département d'Etudes Cognitives, Paris, France

Katrin.Neumann@em.uni-frankfurt.de

Introduction

In a previous fMRI study we detected a stutter-specific activation in the right frontal operculum (RFO, BA 47) (Preibisch et al., 2003). A negative correlation between severity of stuttering and activation in this region suggested that the RFO compensates spontaneously but not very effectively for recently detected structural deficits in the left hemisphere. After a successful fluency shaping therapy, more widespread but more left-hemispheric overactivations have been detected, partly adjacent to the regions with the structural abnormalities. Therefore, a more effective compensation by restoring left-hemispheric networks adjacent to a primary lesion was assumed (lesion-compensation theory; Neumann et al., 2005). Now we tried to corroborate this theory assuming that an optimal compensation can be expected in subjects who completely recovered from stuttering. Therefore, we sought to identify neuronal networks which might be involved in such an "ideal" compensation by examining brain activations with fMRI in subjects who had recovered from stuttering. An evidence for this hypothesis could lead to new insights about efficient stuttering therapies.

Methods and Results

13 male non-stuttering subjects, 13 male subjects who had recovered from stuttering, and 13 male PDS subjects (each of them before and immediately after an intensive fluency shaping therapy course) had to solve verbal tasks. Because data analysis is still in progress, no detailed results can be reported at the time of writing this abstract. First results replicate our former findings of an overactivation in the RFO. Moreover, we detected increased left-hemispheric activations adjacent to the Broca´s region in subjects who had recovered from stuttering.

Discussion

An overactivation in the RFO was also confirmed in the meta-analysis of Brown et al. (2005) and is a robust finding in stuttering subjects. The increased left-hemispheric activations adjacent to the Broca´s region in recovered subjects indicate efficient compensation networks in the left hemisphere in the vicinity of a primary lesion as hypothesized.

References

Brown, S., Ingham, R.J., Ingham, J.C., Laird, A.R., & Fox, P.T. (2005) Stuttered and fluent speech production: an ALE meta-analysis of functional neuroimaging studies. *Human Brain Mapping*, *25*, 105-117.

Neumann, K., Preibisch, C., Euler, H.A., Wolff von Gudenberg, A., Lanfermann, H., Gall, V., & Giraud, A.L. (2005). Cortical plasticity associated with stuttering therapy. *Journal of Fluency Disorders*, *30*, 23-39.

Preibisch, C., Neumann, K., Raab, P., Euler, H.A., Wolff von Gudenberg, A., Lanfermann, H., & Giraud, A.L. (2003) Evidence for compensation for stuttering by the right frontal operculum. *NeuroImage*, *20*, 1356-1364.

THE DUAL PREMOTOR HYPOTHESIS: A NEUROLOGICAL MODEL OF STUTTERING AND SPEECH MOTOR INITIATION

Per A. Alm
Department of Experimental Psychology, University of Oxford, United Kingdom
per.alm@psy.ox.ac.uk (per.alm1@yahoo.com)

Short Overview

Stuttering is a poorly understood speech motor disorder. A striking aspect is the various conditions that tend to temporarily alleviate stuttering: the rhythm effect, unison reading, singing, imitation of a foreign accent, altered auditory feedback, etc. The often remarkable effect of these conditions is likely to provide important clues regarding the basic nature of stuttering.

It is proposed that stuttering is a disturbance of motor circuits passing through the basal ganglia and targeting the *supplementary motor area* (SMA) (Alm, 2004, 2005). An important function of these circuits seems to be to provide "go-signals" for the motor segments in automatized speech. Disturbances of these circuits can result in impaired go-signals as well as dysregulation of muscular control. In Alm (2005) the role of the basal ganglia in stuttering is put in the wider framework of the *dual premotor systems hypothesis* by Goldberg (1985, 1991). It is proposed that most of the fluency enhancing conditions can be explained by the existence of two parallel premotor systems in the human brain: *the medial system* (the basal ganglia and the SMA) and *the lateral system* (the *lateral premotor cortex* and the *cerebellum*).

According to this model both these systems are able to control timing of speech, but with some limitations. In spontaneous speech the control of timing is normally channeled through the medial system. In contrast, when the timing of speech segments is linked to external stimuli (like a metronome), the timing seems to be executed mainly by the lateral system. I.e., the impairment of the medial system is bypassed by the shift to the lateral system.

The lateral system seems to have the ability to control timing of speech also without external input, but this demands an increased level of conscious attention to some aspect of speech. Furthermore, it is argued that also the effect of altered auditory feedback is based on a shift from the medial to the lateral system.

The findings of cortical and white matter anomalies in speech-related regions are discussed. It is suggested (Alm, 2004) that one mechanism causing stuttering is impaired input to the basal ganglia from the motor cortex. Such a disturbance could leave the basal ganglia speech motor circuits out of control, with a disproportionate strong influence of auditory feedback and emotional reactions.

It is proposed that this dual premotor systems model, proposed by Goldberg and others as a general model of motor control, is important both for research on stuttering and for neuroscience studies of speech motor control.

References

Alm, P.A. (2004). Stuttering and the basal ganglia circuits. *Journal of Communication Disorders*, *37*, 325-369.
Alm, P.A. (2005). On the causal mechanisms of stuttering. Doctoral dissertation, Dept. of Clinical Neuroscience, Lund University, Sweden. http://theses.lub.lu.se/postgrad/
Goldberg, G. (1985). Supplementary motor area structure and function: Review and hypotheses. *The Behavioral and Brain Sciences*, *8*, 567-616.

MOTOR TIMING AND FLUENCY

Peter Howell, Jon Bartrip, Andrew Anderson
Department of Psychology, University College London, United Kingdom
p.howell@ucl.ac.uk

Introduction

EXPLAN theory maintains that dysfluency occurs when cognitive-linguistic planning processes are out of synchrony with motor processes (Howell, 2004). The theory applies to fluent and stuttered speech. The essential idea is that motor timing is disrupted when complete linguistic plans are supplied late. EXPLAN predicts motor timing disruption will occur when cognitive-linguistic load is high and that this may be manifest as subtle timing disruption or overt fluency failure. To test the theory, techniques are needed which allow cognitive input to be varied and motor effects to be measured. Two approaches to this issue are reported: The first is based on Smith and Goffman's (2001) STI measure. The second involves new methods for measuring speech rate on spontaneous speech samples. The research questions for the first study are whether a) STI can be adapted to use acoustic-articulatory measures other than lip movement and b) local extracts in individual records can be analyzed. The research question for the second study is whether speech rate is best understood using motor and cognitive-linguistic inputs.

Methods and Results

Study one: STI measures were obtained using equipment like that of Abbs and Gilbert (1973). Fluent speakers and speakers who stutter were employed to provide a range of degres of fluency. They performed the standard 'buy Bobby a puppy' task (Smith & Goffman, 2001). Articulatory measures were extracted from an audio record taken concurrently and processed equivalently to STI. The correlations between the lip STI measure and the measure obtained from the audio record were high. A non-linear technique was also applied to the audio record and allowed stretches of the waveform where fluency control was poor to be delimited.

Study two: Spontaneous speech samples of speakers who stutter were coded with regard to the difficult nuclei in the local surround and the speech rate in the section approaching each nucleus. The two factors together allowed places where fluency breaks down to be predicted.

Discussion

The studies show that techniques that incorporate motor and linguistic measures allow points where timing (study one) and fluency (study two) break down to be delimited.

References

Abbs, J.H. & Gilbert, B. (1973). A strain gauge transduction system for lip and jaw motion in two dimensions: Design criteria and calibration data. *Journal of Speech and Hearing Research*, *16*, 248-256.

Howell, P. (2004). Assessment of some contemporary theories of stuttering that apply to spontaneous speech. *Contemporary Issues in Communicative Sciences and Disorders*, *39*, 122-139. Available at http://www.speech.psychol.ucl.ac.uk.

Smith, A. & Goffman, L. (2001). Interaction of motor and language factors in the development of speech production. In: B. Maassen, et al. (Eds.) *Speech motor control in normal and disordered speech*, *227-252*. Nijmegen: Vantilt.

DISTINGUISHING AMONG MOTOR SPEECH DISORDERS IS IMPORTANT: THE ROLE OF SPEECH PATHOLOGY IN NEUROLOGIC DIAGNOSIS

Joseph R. Duffy
Division of Speech Pathology, Department of Neurology, Mayo Clinic, Rochester, Minnesota, USA
jduffy@mayo.edu

Introduction

The role of speech-language pathologiy in medical diagnosis has traditionally been ignored by medicine and minimized by speech-language pathology. Yet, speech abnormalities can be the first or most prominent sign of neurologic disease. Their accurate, specific diagnosis can help localize the abnormality and sometimes provide valuable clues about the underlying neurologic disease.

This presentation will address the contributions that differential diagnosis of acquired motor speech disorders (MSDs) can make to the localization, diagnosis and management of neurologic disease. These contributions will be highlighted in brief case illustrations and a review of recent and not-so-recent data about the type(s) of MSDs associated with specific neurologic disorders, particularly neurodegenerative disorders. Approaches to improving the clinical reliability, validity, sensitivity and specificity of distinctions among MSDs will be discussed from the perspectives of basic and applied motor speech research and clinical training.

Methods and Results

The primary material for this presentation will be case vignettes and the author's clinical experience. Literature that has contributed to clinicians' ability to differentially diagnose MSDs in the context neurologic diagnosis will be reviewed. The results of a recent study of primary progressive aphasia and apraxia of speech will be used to illustrate the value to clinical and histopathologic neurologic diagnosis of identifying the difference between apraxia of speeech and aphasia and/or dysarthria.

Discussion

The discussion will focus on the underutilized but critical importance of distinguishing among MSDs in the context of localization and diagnosis of neurologic disease. It will also address the critical need for adequate perceptual descriptions of speech in neuroimaging, acoustic, and physiologic studies of MSDs. Only by including perceptual features of MSDs in the literature that studies them can we translate laboratory findings into clinical practice in diagnostically meaningful ways.

References

Duffy, J.R. (2005). *Motor speech disorders: substrates, differential diagnosis, and management*. St. Louis: Elsevier/Mosby.

Duffy, J.R. & Kent, R.D. (2001). Darley's contributions to the understanding, differential diagnosis, and scientific study of the dysarthrias. *Aphasiology*, *15*, 275-289.

Kent, R.D., Duffy, J.R., Slama, A., Kent, J.F., & Clift, A. (2001). Clinicoanatomic studies in dysarthria: review, critique, and directions for research. *Journal of Speech, Language, and Hearing Research*, *44*, 535-551.

THE RELATIONSHIP BETWEEN VOICE ACOUSTICAL CHANGE AND DIMINISHMENT IN STRIATAL DOPAMINE TRANSPORTERS IN EARLY PARKINSON'S DISEASE

Peter J. Snyder[1,2], Kenneth Marek[3], Paul Maruff[4], Henri Cohen[2]
[1]Department of Psychology, Univ. of Connecticut, Storrs, CT, USA, [2]Cognitive Neuroscience Center, Univ. du Québec à Montréal, Qc., Canada, [3]Institute for Neurodegenerative Diseases, New Haven, CT, USA, [4]CogState, Ltd., Melbourne, Australia.
peter.snyder@uconn.edu

Introduction

Idiopathic Parkinson's disease (PD) is associated with loss of dopamine (DA) in the brain, and it is marked by impairments of both speech and non-speech motor control. Although at least 50% of PD patients eventually show a hypokinetic dysarthria, it is unclear how subtle changes in speech motor control manifest in the early stages of PD, and how they might reflect increasing damage to the striatal DA system over time. Our goal was to relate change in voice acoustics (VA) to change in SPECT imaging of striatal DA tone over the early course of this disease.

Methods and Results

Eight mild PD patients completed exams at 0, 12 and 24-36 months post-baseline, including measures of mean fundamental frequency (F0) for held vowels and diadochokinetic (DDK) speaking rate. SPECT imaging ($^{[123]}$I-ß-CIT ligand; Seibyl et al., 1995), focused on the putamen contralateral to the side of symptom onset for each subject. Within-subjects change over time, for all variables, were compared using a modified Dunlap's *d* statistic (Snyder et al., 2006).

Change over the first 12 months in striatal DA transporters (DAT) was observed (d = -0.90), and at 24-36 months the magnitude of this decrease in DAT rose to d = -2.79 (p=.001). A nearly identical pattern of reliable change was observed in DDK rate, comparing baseline to 12 months (d = -1.27, p=.031) and 24-36 months (d = -2.64, p=.001). Similar changes over time in (increased) mean F0 for sustained vowels were observed.

Discussion

This may be a first report of a direct comparison of change over time in several voice acoustics measures with change in striatal DA tone in mild PD patients. In our sample, the magnitude of change over a 2-3 year period in striatal DAT is consistent with that observed for changes in DDK speech rate and mean F0 for sustained vowels. Voice acoustical changes that are often observed early in PD may reflect changes in striatal dopaminergic tone.

References

Seibyl, J.P., et al. (1995). Decreased single-photon emission computed tomographic [123I]beta-CIT striatal uptake correlates with symptom severity in Parkinson's disease. *Annals of Neurology*, *38(4)*, 589-98.

Snyder, P.J., Werth, J., Giordani, B., Caveney, A.F., Feltner, D., & Maruff, P. (in press). A statistical approach for classifying change in cognitive function in individuals following pharmacologic challenge. An example with alprazolam. *Psychopharmacology*.

THREE-DIMENSIONAL ULTRASOUND IMAGING OF THE TONGUE FOLLOWING PARTIAL GLOSSECTOMY SURGERY: ASSESSMENT OF GROOVING AND SYMMETRY

Tim Bressmann[1], Elizabeth Ackloo[1], Yarixa Barillas[1], Jonathan C. Irish[2]
[1]*Department of Speech-Language Pathology, University of Toronto,*
[2]*Princess Margaret Hospital, University Health Network, Toronto, Canada*
tim.bressmann@utoronto.ca

Introduction

The speech outcomes following partial tongue resection and reconstruction are often highly variable. Our understanding of the impact of a partial tongue resection and reconstruction on the three-dimensional shape of the tongue in speech is limited. The purpose of the present study was to develop meaningful qualitative and quantitative indicators for lingual protrusion, grooving and symmetry in patients undergoing partial glossectomy surgery.

Methods and Results

Fourteen patients with lateral lingual tumours were seen before their surgery and 2 months after the operation. Twelve normal participants served as controls. The three-dimensional ultrasound volumes of 9 sustained speech sounds were acquired using a 3D rendering workstation. These volumes were measured in three parallel sagittal planes. The resulting data were analyzed using principal component analyses. We also calculated measures related to tongue protrusion (anteriority index), midsagittal grooving (concavity index), and symmetry (asymmetry index).

The results showed no statistically significant differences between the tumour patients preoperatively and the controls. Postoperatively, the surface plots and the principal components demonstrated deviant patterns that indicated a decrease in symmetry of the tongue shapes. The postoperative concavity values were significantly lower and the postoperative asymmetry values were significantly higher than those of both the patients preoperatively and the normal controls.

Discussion

Three-dimensional ultrasound imaging offers new insights into the biomechanical properties of partial glossectomees' tongues. The research allowed us to identify important commonalities across a group of patients. In particular, a lateral resection affects the tongue's ability to form a midline groove as well as its symmetry. Since all the resections in this study were confined to the lateral oral tongue, the tongue's ability to protrude remained unaffected. The findings have implications for surgical strategies for lingual defect reconstruction.

References

Bressmann, T., Heng, C.-L., & Irish, J.C. (2005). The application of 2D and 3D ultrasound imaging in speech-language pathology. *Journal of Speech-Language Pathology and Audiology*, *29*, 158-168.

Bressmann, T., Uy, C., & Irish, J.C. (2005). Analyzing normal and partial glossectomee tongues using ultrasound. *Clinical Linguistics and Phonetics*, *19*, 35-52.

DEVELOPMENTAL MODELS OF CHILDHOOD APRAXIA OF SPEECH (CAS)

Ben Maassen[1,2,3], Lian Nijland[1,3]
[1]Medical Psychology; [2]Paediatric Neurology; [3]ENT
Radboud University Medical Centre, The Netherlands
b.maassen@cukz.umcn.nl

Short Overview

Since the critical review by Guyette and Diedrich in 1981 on Developmental Apraxia of Speech (DAS) as a diagnostic entity, many approaches have been suggested to solve the diagnostic problem of differentiating DAS from other childhood speech disorders. Shriberg et al. (1997) extensively discussed diagnostic features and the theoretical perspectives these are based on. The discussion comprises two fundamental issues. The first concerns the underlying speech production model. Although researchers seem to agree that DAS –just as acquired apraxia of speech in adults (AOS)-- is a speech motor disorder, no agreement exists on the demarcation between psycholinguistic and motor control processes. In the terminology of sequential production models: When does phonological encoding end its process, and when do the processes motor planning and motor programming take over? Is it the 'syllabary' that forms the transition between psycholinguistic and motor processes? Related to this modelling question is the issue whether the origin of particular speech phenomena or speech symptoms can be traced to particular stages in speech production. Recently Ziegler (2005) suggested a hierarchical, computational control model for AOS, rather than a sequential model. Such an approach questions the idea that the speech disorder AOS can be located at a particular processing level; it rather suggests that it is the type of information processing (sequencing, combining elements) that is involved across levels of speech production.

The second fundamental issue is related to development. Development is constituted of a continuous process from repetitive and variegated babbling, to single word production and more-word utterances, in which speech motor control interacts with auditory, higher-order representational and information processing capacities. Early phonology is not an abstract representation of contrasts and rules, but very much implemented as auditory, kinesthetic, tactile and articulatory constriction representations or 'reference frames' (Guenther et al., 1998).

Clinical research on these interactive and developmental processes in speech disorders is fragmentary, and conducted from diverse theoretical viewpoints and clinical questions. In this presentation we will review the relevant literature on CAS, argue for the CAS-subtype DAS, and present data from our own lab suggesting that a general combinatorial deficit across processing levels underlies DAS.

References

Guenther, F.H., Hampson, M., & Johnson, D. (1998). A theoretical investigation of reference frames for the planning of speech movements. *Psychological Review, 105,* 611-633.

Shriberg, L.D., Aram, D.M., & Kwiatkowski, J. (1997). Developmental apraxia of speech: I. Descriptive and theoretical perspectives. *Journal of Speech and Hearing Research, 40,* 273-285.

Ziegler, W. (2005). A nonlinear model of word length effects in apraxia of speech. *Cognitive Neuropsychology*, *22*, 1-21.

RESEARCH IN IDIOPATHIC AND SYMPTOMATIC CHILDHOOD APRAXIA OF SPEECH

Lawrence D. Shriberg
Waisman Center, University of Wisconsin-Madison, WI, USA
shriberg@waisman.wisc.edu

Short Overview

One methodological approach to the circularity issues that constrain explanatory research in Childhood Apraxia of Speech (CAS) is to study such children in each of three clinical contexts in which CAS has been reported – pediatric neurological disorders (e.g., a sequela of infection, stroke, trauma), complex neurodevelopmental disorders (e.g., epilepsy, galactosemia), and as an idiopathic pediatric speech sound disorder. Almost all programmatic research has focused on children in the latter group, which, by definition, lacks common grounding of subjects on some known biological processes. The research framework described in the present report posits that studies of CAS occuring in complex neurodevelopmental disorders – in which subjects share common biobehavioral processes – provides a way to inform theory, and ultimately, practice. The general goal is to accumulate findings across diverse study samples, towards an eventual understanding of the pathophysiology of the praxis deficit underlying all etiological forms of CAS.

The first section of the presentation provides a brief overview of classification research in speech sound disorders and methodological needs in CAS research. The second section reviews genetic studies of CAS in complex neurodevelopmental disorders, including CAS reported in persons with deficits in *FOXP2*, and similar speech deficits associated with translocations affecting other genetic regions of interest. These papers include cytogenetic and mapping studies that have yielded a total of 34 cases in which speech sound disorders consistent with CAS have been reported in the context of a genetically-based, complex neurodevelopmental disorder.

Discussion and conclusions will be integrated within the format of the Minisymposium on Developmental Apraxia of Speech.

References

Ballard, K.J., Shriberg, L.D., Duffy, J.R., & Tomblin, J.B. (2006). A motor speech disorder associated with a balanced 7:13 translocation affecting FOXP2. *Manuscript submitted for publication.*

Shriberg, L.D., Ballard, K.J., Tomblin, J.B., Duffy, J.R., & Odell, K.H. (in press). Speech, prosody, and voice characteristics of a mother and daughter with a 7;13 translocation affecting *FOXP2*. *Journal of Speech, Language, and Hearing Research.*

SCIENCE AND CLINICAL PRACTICE IN CHILDHOOD APRAXIA OF SPEECH

Donald A. Robin
University of Texas Health Science Center, San Antonio and University of Texas, San Antonino
drobin@mail.sdsu.edu

Short Overview

This paper will provide a discussion of the role of science and research as necessary endeavors to improve and advance clinical practice in Childhood Apraxia of Speech (CAS). First, it will be argued that distinctions between basic and applied science are inappropriate. Thus, any notion that one type of science is intrinsically better than another is inherently false. Importantly, the obvious notion that science undergirds clinical professions will be the cornerstone of this talk. Second, the role of science in understanding, diagnosing and treating CAS will be discussed with particular reference to the role of science in (1) the development of an operational definition of the disorder, (2) the specification of differential features of CAS, (3) obtaining prevalence estimates of the disorder, (3) the delineation of underlying neuro- and psychopathology of CAS, and (4) the treatment of the disorder. While certain investigators and clinicians have begun to fine tune an operational definition and explore differential features of CAS, there continues to be controversy about identification of children with CAS and therefore inclusion criteria for research protocols depend on relatively vague symptoms. Of critical importance is the fact that research on CAS is relatively scarce, even with the finding that the disorder has a genetic form. Moreover, this lack of research has stymied efforts to increase academic training in the area of CAS and has hampered funding projects in this area. Finally, recent advances in understanding motor programming will be used to provide theoretical support for CAS at a neuropsychological level.

USING SOMATOSENSORY INFORMATION TO ENHANCE ORAL COMMUNICATION, COGNITIVE AND LINGUISTIC SKILLS IN CHILDREN WITH CAS

Deborah Hayden
The PROMPT Institute, Santa Fe, New Mexico, USA
deb@promptinstitute.com

Introduction

In the last decade several researchers have proposed that "perception-action linkages may be modulated or changed due to the effect from either sensory or cognitive influences". These recent findings suggest that especially during developing speech and language there may be a critical interface between the somatosensory and cognitive-linguistic systems. The key question and the focus of this presentation is does "active" tactual- kinesthetic- proprioceptive information applied differentially and systematically to the neurological system support speech subsystem change and the development and/or association of cognitive-linguistic information particularly in children with compromised cognitive and motor speech systems.

Methods and Results

Three clinical efficacy studies are presented (Hayden & Sherman, 1983; Square & Hayden, 2000; Rogers & Hayden, 2004) that explore the relationships between developmental level and disorder, tactual sensory inputs for oral production, intervention structure and the resulting improvements in both speech subsystem development and cognitive-linguistic growth. All studies were of single subject or multiple probe design. Populations included CAS (with and without accompanying focal oral motor dysfunction) and autism. Eighteen children, ages 24 months- 11 years were studied. The results of all studies reinforce the hypothesis that "active" tactual-kinesthetic information, systematically applied (e.g. PROMPT) adds to and supports auditory and visual information for both speech motor control development and mapping of cognitive-linguistic information. This hypothesis appears to hold regardless of age however the developmental level (especially pre-linguistic) does have a direct impact on the type of vocalizations and concepts trained.

Discussion

Critical points for discussion and further research include: 1.) the interface between cognitive-linguistic and physical sensory systems, especially during early development and pre-linguistic stages where it is hypothesized that children need especially strong linkages between sensori-motor (i.e., tactual, auditory and visual) information and cognitive-linguistic systems; 2.) how the course of learning may be affected by, sensory, cognitive or emotional aspects and the demands on central resourcing in both perceptual and motor learning, 3.) Finally, there is need for research that documents the contributions of the somatosensory systems to speech motor control for both planning and executing oral language events.

References

Hayden, D. (2004). PROMPT: A tactually grounded treatment approach to speech production disorders. In: I. Stockman (Ed.) *Movement and action in learning and development: Clinical implications for pervasive developmental disorders*, 255-298. New York: Elsevier.

Kent, R. D. & Vorperian, H. K. (in press). In the mouths of babes: anatomic, motor, and sensory foundations of speech development in children. To appear in: R. Paul (Ed.) *Language Disorders from a Developmental Perspective*. Mahwah, NJ: Lawrence Erlbaum.