Bilingualism and the Brain in Education and Language (BABEL) Lab

Genesis Arizmendi, PhD, CCC-SLP

Mathematical problem solving in emergent bilingual children: Is growth related to the navigation between two working memory systems?

Authors: H. Lee Swanson, Genesis D. Arizmendi, and Jui-Teng Li.

This study explored how bilingual children's memory skills influence their ability to solve math word problems. Researchers followed 429 Spanish-English bilingual elementary students over three years, testing their memory, language, and math abilities in both Spanish and English. The findings revealed that three key parts of memory—short-term memory (STM), visual-spatial memory, and executive memory—play a significant role in math problem-solving. Improvements in STM and executive memory were particularly important, especially as these skills worked together more effectively in English. Importantly, memory skills in Spanish also boosted children's math abilities in English, showing that strong first-language skills can enhance learning in a second language. Growth in memory skills in both Spanish and English contributed independently to better math performance, regardless of a child's overall academic abilities. These results emphasize the value of supporting bilingual children's development in both languages, underscoring the role of native language skills in fostering academic success.

Language and Cognition Lab

Leah Kapa, PhD

Statistical learning among preschoolers with and without developmental language disorder: Examining effects of language status, age, and prior learning.

Authors: Leah L. Kapa and Heidi M. Mettler.

The purpose of this research was to compare statistical learning abilities between preschool-age children with and without developmental language disorder (DLD), which is a neurodevelopmental disorder affecting expressive and receptive language acquisition. Statistical learning is the process of recognizing patterns implicitly (i.e., without consciously trying). To test this, we presented children with simple artificial grammars and tested their knowledge of the grammatical rules. Example training items in the grammar are *poe ralza* and *poe gipta*. Test items provided new examples that either followed (e.g., *poe falsa*) or violated (e.g., *falsa poe*) the grammatical rules. Participants rated whether each test item was correct or incorrect. Four-year-olds with and without DLD performed equivalently, and children in this age group did not learn the grammar. In contrast, five-year-olds with typical language learned the grammar and performed better than five-year-olds with DLD who did not learn the grammar. These findings highlight the impaired language learning system in children with DLD because they are unable to learn the grammar when typical peers can after the same amount of training. Results also demonstrate developmental changes in the preschool period as typically developing four-year-olds did not demonstrate learning in our task, but typically developing five-year-olds did.

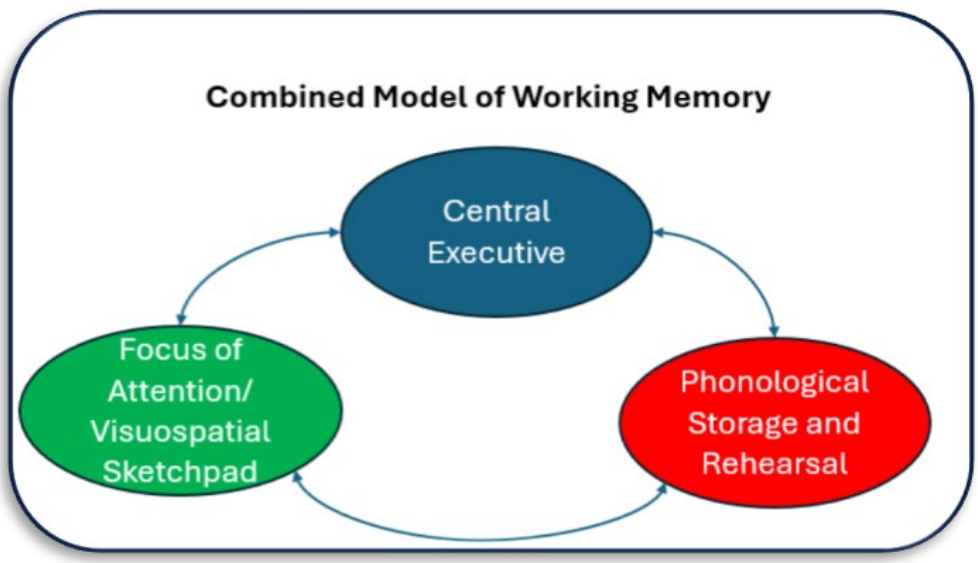
L4 Lab: Language, Learning, Literacy, Lexicon

Mary Alt, PhD, CCC-SLP

Working memory structure in young Spanish-English bilingual children.

Authors: Mary Alt, DeAnne R. Hunter, Roy Levy, Sarah Lynn Neiling, Kimberly Leon, Genesis D. Arizmendi, Nelson Cowan, and Shelley Gray.

Working memory is what we use to hold information in mind and manipulate it before we either forget it or commit it to long term memory. It is an important predictor of academic success. However, there is very little information available on working memory models for bilingual Spanish-English speaking children. So, we tested a three-factor model of working memory that was a good fit for monolingual children to see if it worked for bilingual children. The model included a Central Executive component (which controls how information is processed), a component for phonology (sound system of language, including rehearsal) and a visual/focus of attention component (visual information and attention without rehearsal). Using data from 80 Spanish-English bilingual children, we were able to verify that the model was a good fit for bilingual children, marking new knowledge about this important bilingual cognitive mechanism. Knowing that the models were equivalent, we were able to compare performance across monolingual and bilingual participants, controlling for socioeconomic status. While there were differences between the groups on each of the components there was too much uncertainty to interpret those differences. Basically, we need a lot more work to understand potential differences between learners.



L4 Lab: Language, Learning, Literacy, Lexicon

Not all planes have propellers: Using context variability to treat word learning in late talkers with the VAULT protocol. Authors: Mary Alt, Heidi M. Mettler, Elissa S. Schiff, Nora Evans-Reitz, Rebecca Burton, Sarah R. Cretcher, and Allison Staib. (accepted)

Late-talking toddlers learn words at slower rates than typically developing toddlers for no known reason. In this study, we taught late talking toddlers new words using the Vocabulary Acquisition and Usage for Late Talkers (VAULT) treatment. VAULT is play-based and designed using principles of statistical learning, which is a type of learning people do without even realizing they are learning. VAULT is all about the input: the clinician says a set of target words in grammatical sentences at a rate of nine times per minute. The idea is that hearing a target word multiple times in varied contexts will help the child recognize the word and be able to produce it. By learning this way – through recognizing patterns – we hope that children will also 'learn to learn' by picking up on patterns of words in their environment.

Previous studies have shown that VAULT is effective in getting children to produce words that they already understand, but do not say. We found that we could teach children new words that they did NOT understand at the start of treatment. We were excited to learn that we could successfully expand the scope of our treatment.

L4 Lab: Language, Learning, Literacy, Lexicon

Jessie Erikson Pyarelal, PhD, CCC-SLP

Science vocabulary and science achievement of children with language/literacy disorders and typical language development.

Authors: Jessie A. Erikson, Mary Alt, Adarsh Pyarelal, and Leah L. Kapa.

This goal of this study was to examine relationships between science vocabulary, language skills, and state science achievement test scores among children with language/literacy disorders (i.e., developmental language disorder and/or dyslexia) and typical language development. We found that children with language/literacy disorders knew fewer science words and provided poorer definitions than their peers with typical language development. They also earned lower science test scores. We found that students who knew more science words and provided more detailed definitions of science words had higher science scores. Children with stronger language skills also had higher science scores. These findings have two major implications. First, multiple aspects of science vocabulary knowledge – both the number of science terms students know (breadth) and how well they know science terms (depth) – may be important for science achievement. Second, children with language/literacy disorders are at risk of having more limited science vocabulary knowledge and lower levels of science achievement. Together, our findings suggest that supporting science vocabulary knowledge could be one way to improve science achievement outcomes for students with language/literacy disorders.

Language and Neuroimaging Research Lab

Aneta Kielar, PhD

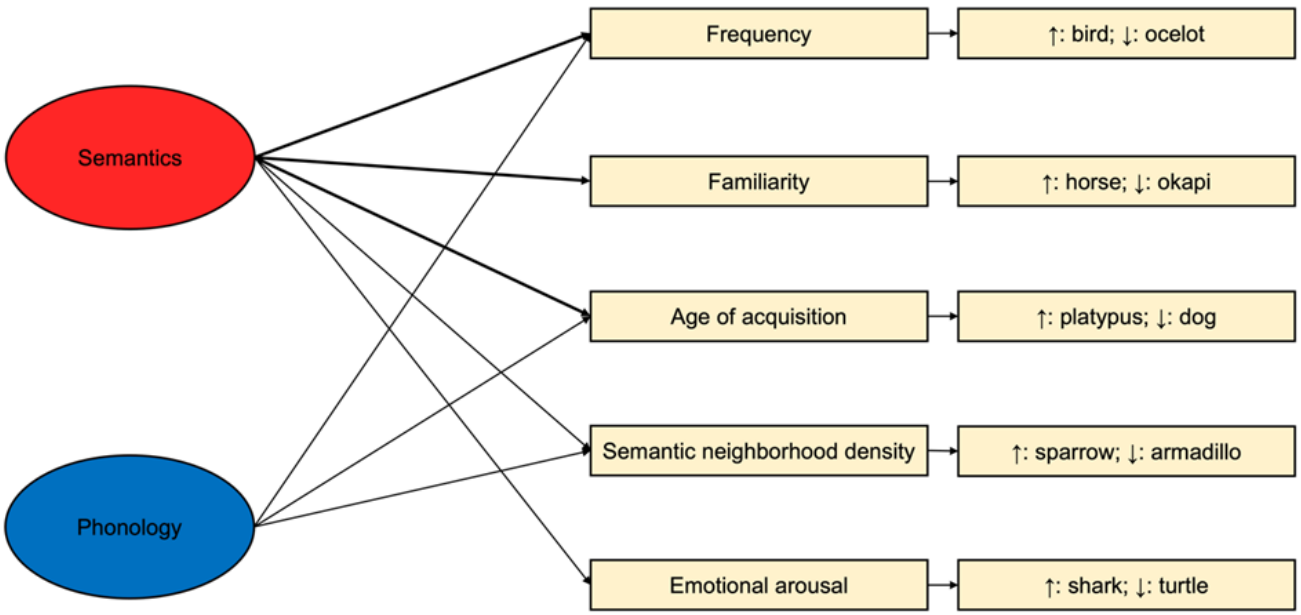
Katlyn Nickels, PhD

Fatima Jebahi, M.S.

Patterns of performance on the animal fluency task in logopenic variant of primary progressive aphasia: A reflection of phonological and semantic skills.

Authors: Fatima Jebahi, Katlyn V. Nickels, and Aneta Kielar.

This study explored how individuals with a language disorder called logopenic variant primary progressive aphasia (lvPPA) perform on a common test of word retrieval: naming as many animals as possible in one minute. The goal was to understand not only how many words they could generate but also the types of words they produced and what these reveal about their language abilities. Compared to typical adults, people with lvPPA named fewer animals and tended to say words they learned earlier in life, like "dog" or "cat." Within the lvPPA group, those who performed better were able to name animals that are learned later in life, like "rhinoceros." Their performance was influenced by two key language abilities: phonology (processing of sounds) and semantics (processing of meaning). These abilities affected how many words they produced and the kinds of words they retrieved. For example, people with stronger semantic skills were better at recalling familiar and emotionally engaging words, while phonological abilities helped them retrieve words learned later in life. This research sheds light on the interplay between sound and meaning in word retrieval, helping us better understand language challenges in lvPPA.

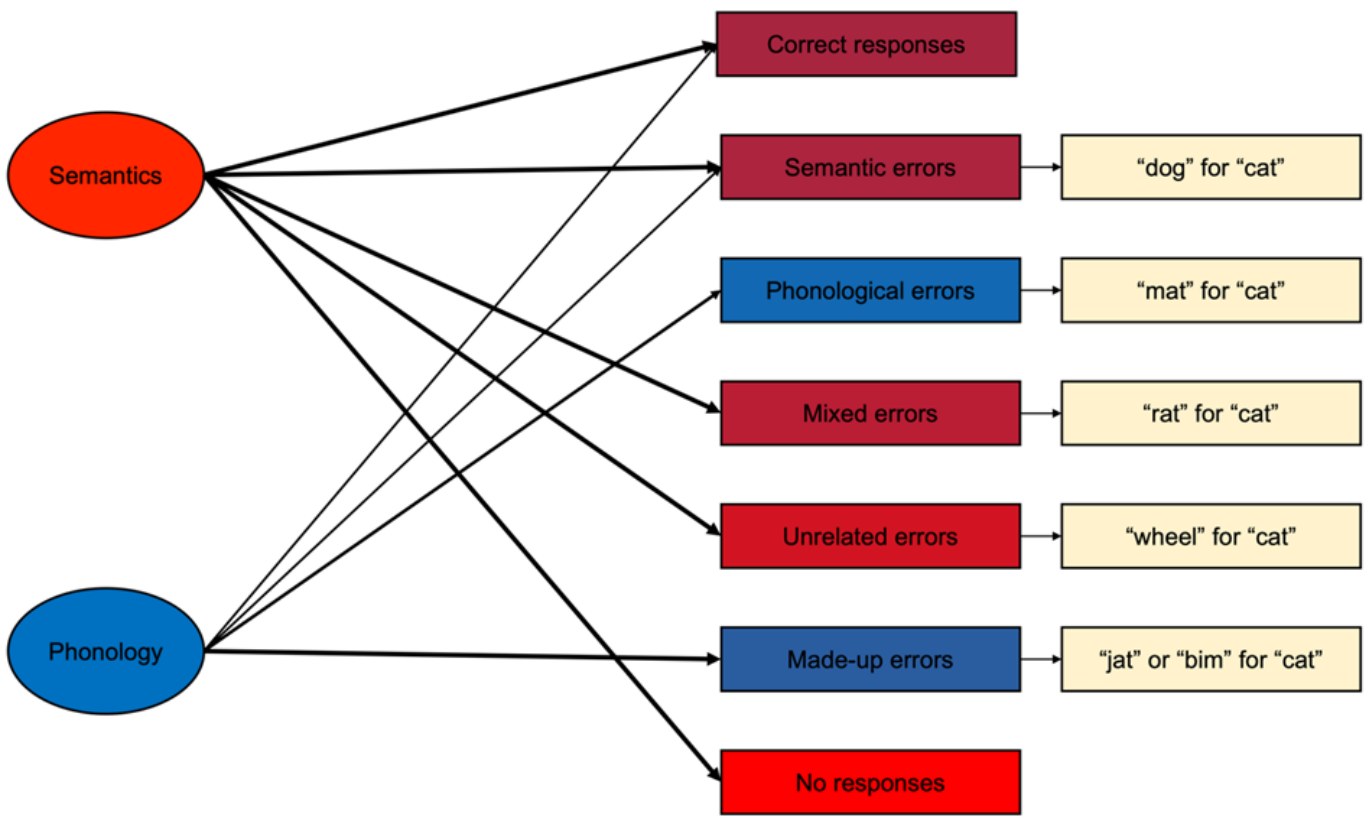


Language and Neuroimaging Research Lab

The relationship between semantics, phonology, and naming performance in aphasia: A structural equation modeling approach.

Authors: Fatima Jebahi and Aneta Kielar.

This study investigated how two key language abilities—semantics (word meaning) and phonology (word sounds)—influence naming performance and the types of errors made by individuals with aphasia, a language disorder commonly caused by stroke. Using advanced statistical modeling with data from 296 participants, we examined how these abilities relate to naming accuracy and different error types. Semantic abilities played a critical role in reducing errors: individuals with stronger semantic skills made fewer meaning-related mistakes (e.g., calling a "cat" a "dog"), mixed errors (e.g., saying "rat" for "cat"), unrelated errors (e.g., calling a "cat" a "wheel"), and instances of being unable to respond. Phonological abilities were linked to fewer sound-based errors (e.g., saying "mat" for "cat") or made-up words, but unexpectedly contributed to more meaning-related errors (i.e., individuals with better phonological abilities committed more meaning-related errors). These findings emphasize the importance of understanding the distinct roles of sound and meaning in word retrieval. By identifying the specific contributors of each type of naming error, this research can guide clinicians in developing targeted therapies that address the core language challenges faced by individuals with aphasia.

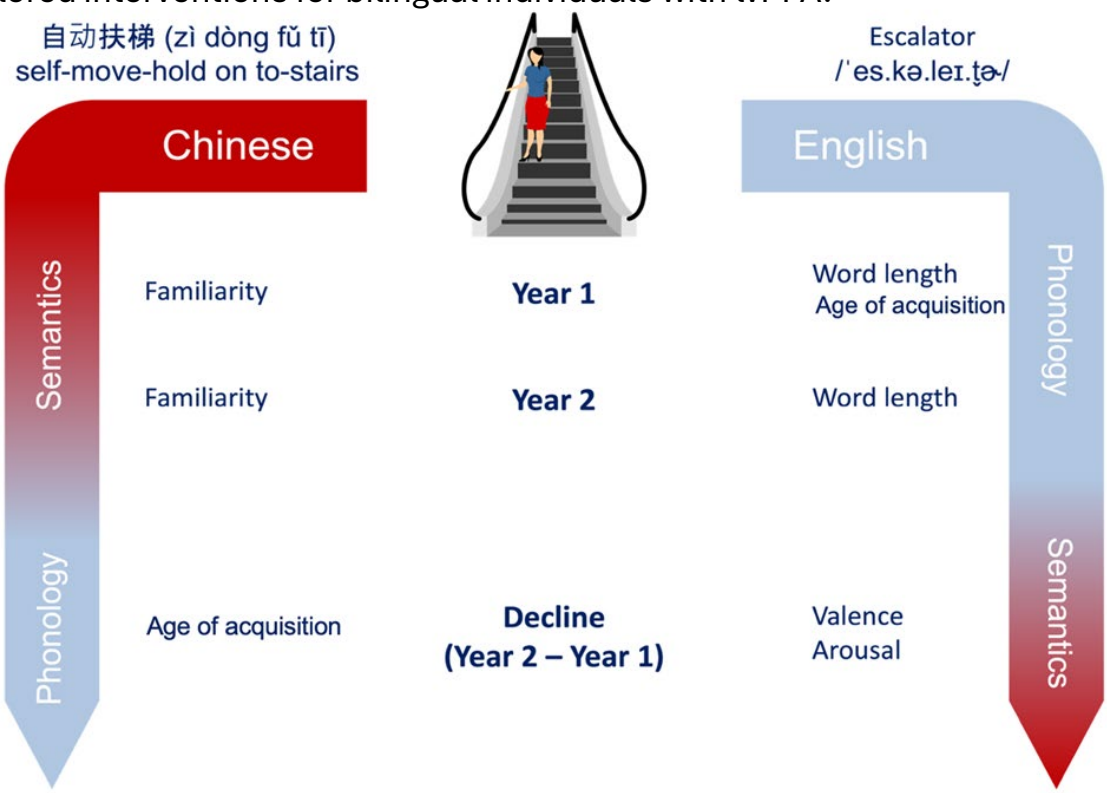


Language and Neuroimaging Research Lab

Psycholinguistic predictors of naming accuracy and decline in bilingual logopenic primary progressive aphasia: A cross-linguistic case study.

Authors: Fatima Jebahi, Vicky Tzuyin Lai, and Aneta Kielar. (accepted)

This study examined how naming abilities were affected in a bilingual individual with logopenic variant primary progressive aphasia (lvPPA), a language-based dementia that impairs word retrieval. We followed a 78-year-old Chinese-English bilingual woman over two years to investigate how naming accuracy changed in her two languages: her first language (Chinese) and her more frequently used second language (English). The results revealed that her naming accuracy was consistently better in English, the language she used more often, compared to Chinese, despite Chinese being her first language. Interestingly, there was little overlap in the words she could name correctly in each language. Factors influencing naming accuracy were language-specific: in Chinese, accuracy was predicted by how familiar a word was, while in English, shorter words and those learned earlier in life were easier to name. Naming decline was also influenced by different factors—words learned earlier in life were more vulnerable in Chinese, while positive emotional words declined slower in English. These findings highlight how lvPPA affects each language differently in bilingual individuals. Understanding the specific factors influencing naming performance in each language can help clinicians design more tailored interventions for bilingual individuals with lvPPA.



Lifespan Language Lab

Nell Maltman, PhD

Language use predicts symptoms of fragile X-associated tremor/ataxia syndrome in men and women with the *FMR1* premutation.

Authors: Nell Maltman, Audra Sterling, Ellery Santos, and Randi Hagerman.

Dr. Maltman and colleagues from UW-Madison and the UC-Davis MIND institute, evaluated language features among both men and women with symptoms of Fragile X-Associated Tremor/Ataxia Syndrome (FXTAS) using a five-minute monologue language sample. FXTAS is a condition caused by a genetic mutation on the X chromosome. The study team found no differences in speech and language features between men and women but did find that language predicted FXTAS severity and cognitive symptoms of the condition. Specifically, slower rate of speech, lower lexical diversity (different words), and higher rate of dysfluencies were predictors of more severe symptoms. This suggests language changes may occur as part of the FXTAS symptom profile.

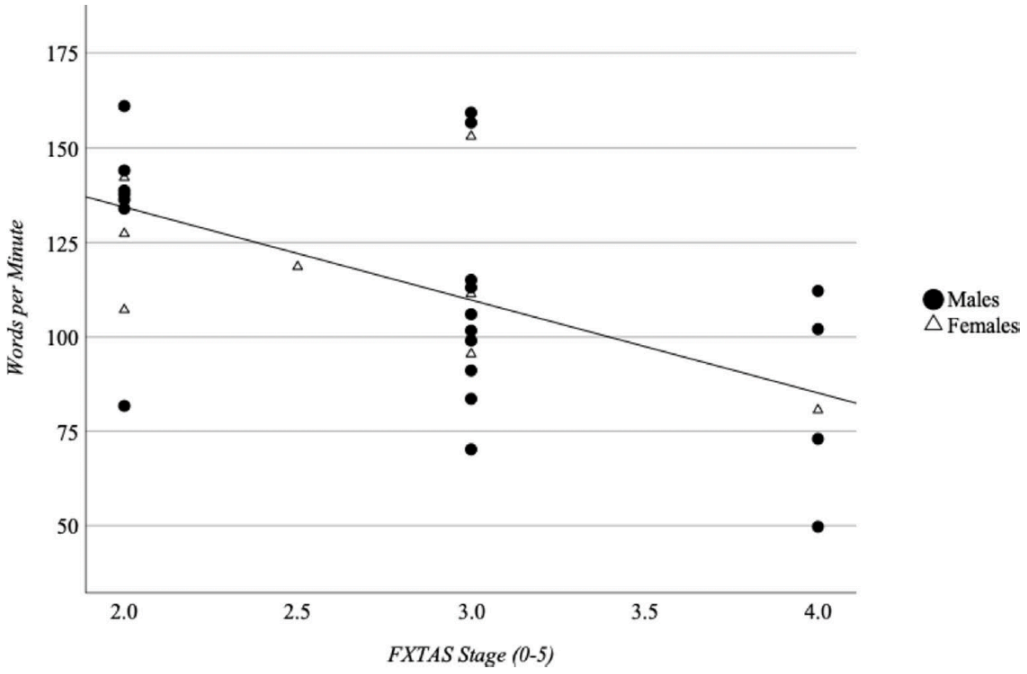


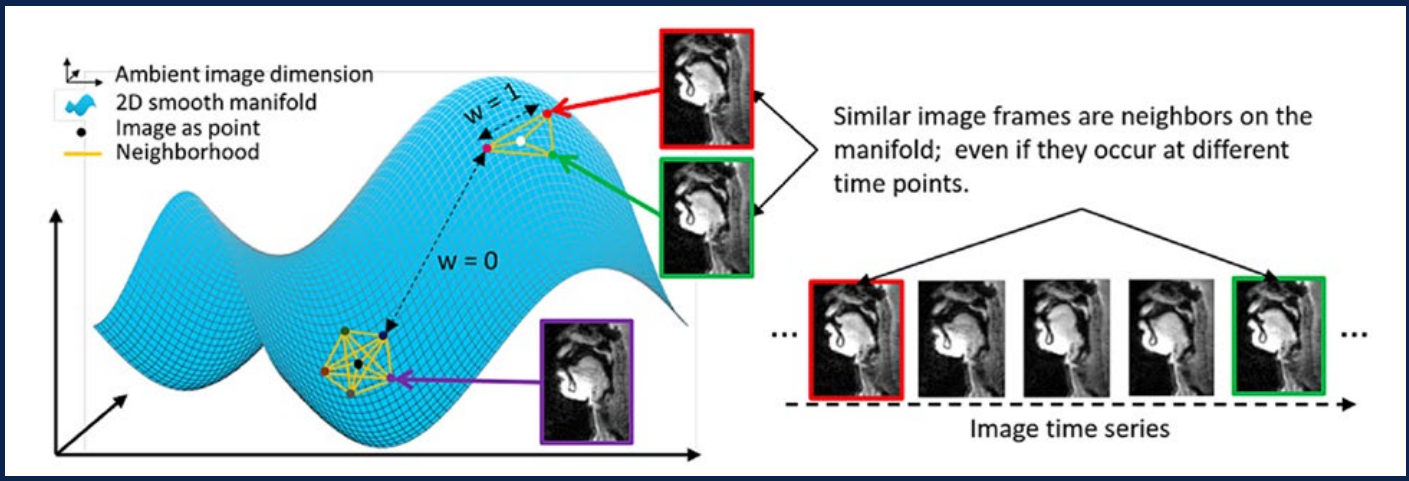
Fig. 1. Relationship between speech rate and FXTAS-associated symptoms. This figure represents the association between Words per Minute (i.e., speech rate) and predicted FXTAS Stage. FXTAS stage was rated from 0 (no symptoms) to 5 (definite and severe FXTAS symptoms). Fewer words per minute predicted greater FXTAS severity (Estimate = -.045, Wald $\chi^2 = 8.20$, p=.004; pseudo $R^2 = .38$), above and beyond the effects of age and sex.

Speech Acoustics and Physiology Lab (SAPL)

Brad H. Story, PhD

Prospectively accelerated dynamic speech MRI at 3 Tesla using a self-navigated spiral based manifold regularized scheme. Authors: Rushdi Zahid Rusho, Abdul Haseeb Ahmed, Stanley Kruger, Wahidul Alam, David Meyer, David Howard, Brad H. Story, Mathews Jacob, and Sajan Goud Lingala.

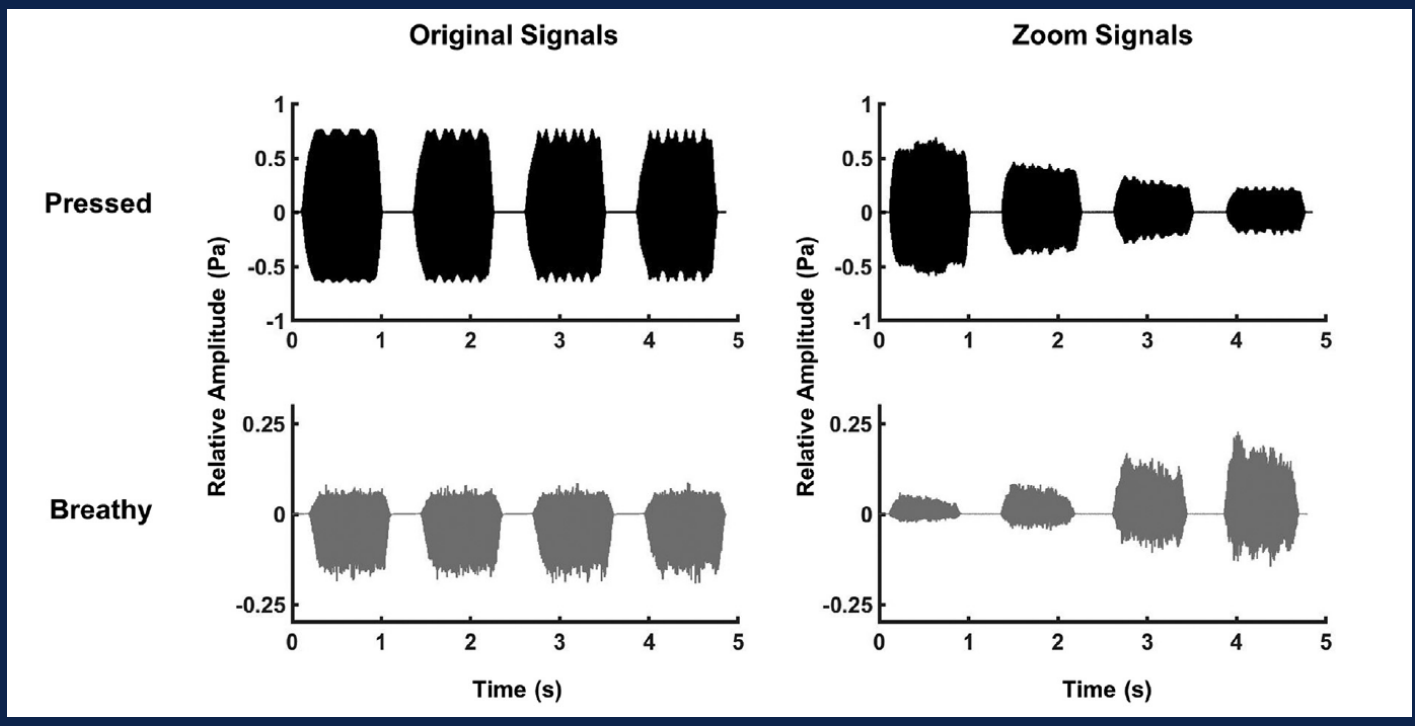
Magnetic Resonance Imaging (MRI) has been used extensively to study the shape of the human vocal tract (i.e., windpipe, throat, mouth, nose) during speech. Because of the slow speed of image acquisition, much of the research on speech using MRI has been focused on individual speech sounds such as sustained vowels. In recent years, however, techniques have been developed that allow for more rapid image acquisition and move us closer to being able to capture a moving image of a person speaking a phrase or sentence. In this study, a novel approach was proposed for rapid acquisition of dynamic speech using MRI and achieved single-slice imaging with frame rate of nearly frames per second (as comparison, standard video is 30 frames/sec). This approach demonstrated increased fidelity in capturing speech motion patterns compared with other existing algorithms. The figure below is graphical representation of the image processing algorithm.



Speech Acoustics and Physiology Lab (SAPL)

The effects of remote signal transmission and recording on acoustical measures of simulated essential vocal tremor: Considerations for remote treatment research and telepractice. Authors: Rosemary A. Lester-Smith, Charles G. Jebaily, and Brad H. Story.

Online meeting technologies such as Zoom offer many possibilities for meeting remotely with clients, patients, and study participants. The aim of this study was to determine if speech recorded in an online session would provide a signal quality that is sufficient for making accurate acoustical measurements relevant to vocal tremor (i.e., shaky voice). To provide control signals for which the characteristics of vocal tremor are known a priori, a computational model of speech production was used to simulate human-like speech with varying degrees of vocal tremor. These signals were transmitted from one computer to another via a Zoom meeting to emulate a client producing speech remotely and recorded by a clinician at a clinic location. Acoustic analyses were performed on the original signals and the remote-recorded versions. Results showed that acoustical measures that correlate to perception of vocal tremor and voice quality were altered by remote signal transmission and recording. Therefore, acoustical assessments of vocal tremor should be performed using audio recordings that are collected locally on the participant- or client-end. The figure below shows an example of how Zoom altered the original signals.



Speech Acoustics and Physiology Lab (SAPL)

An approach to explaining formants. Author: Brad H. Story.

A fundamental concept for understanding how information is transmitted from one person to another by producing speech is the notion of “formant frequencies” or “formants”. A formant is a frequency band in the acoustic speech spectrum where the energy is prominent. The presence of three or more of these bands of energy serves as the primary carrier of phonetic information that forms a message for a listener. The formants are generated by combination of a talker’s voice source (sound produced by the larynx) and the shape of the throat and mouth (called the vocal tract) at any given instant of time. This article was designed to provide instructors of speech science courses a visual framework for teaching the nature of formants. The figure below shows spectrographic representations (time, frequency, amplitude) of the voice source, vocal tract, and speech output for a phrase. The supplementary material that accompanies the article include 3D animations and audio files that can be used in a classroom setting.

Output

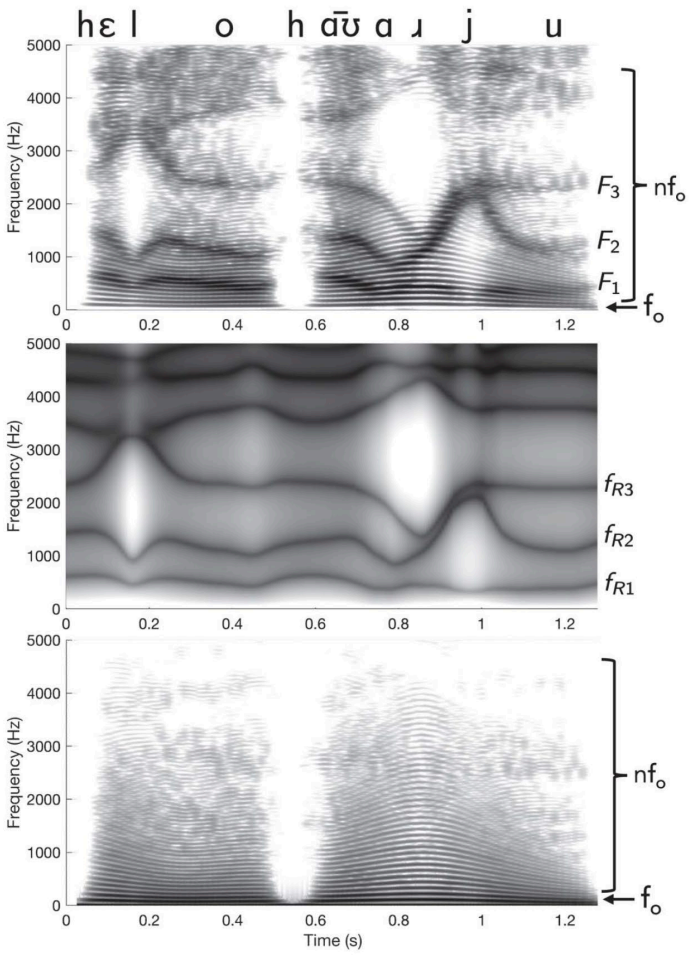
- The acoustic energy of the source is shaped by the vocal tract resonances (filter) into formants to produce an output sound containing characteristics of both source and filter.
- Formants are denoted as F_1, F_2, F_3, ...

Filter

- Time-varying vocal tract = time-varying acoustic resonances at frequencies determined by the vocal tract shape at given instant of time.
- Resonances are denoted as f_{R1}, f_{R2}, f_{R3},...

Source

- Fundamental frequency, f_o
- Harmonics, nf_o
- Raw acoustic energy for speech/song



Speech Acoustics and Physiology Lab (SAPL)

Kate Bunton, PhD, CCC-SLP

Gap size measured on MRI during sustained phonation correlates with perceptual ratings of hypernasality in connected speech.
Authors: Jessica L. Williams, Jamie L. Perry, Kate Bunton, Kelly Nett Cordero, Taylor D. Snodgrass, Davinder J. Singh, Hamy Temkit, and Thomas J. Sitzman.

Does successful surgical treatment of velopharyngeal insufficiency aid in the remediation of compensatory misarticulation errors?
Authors: Jessica L. Williams, Kate Bunton, Elizabeth Alvarez-Montoya, Kelly Nett Cordero, Jamie L. Perry, Jennifer Philp, Davinder J. Singh, and Thomas J. Sitzman. (accepted 11-21-24)

Vestibular Research Lab

Megan Kobel, AuD, PhD

Associations Between Vestibular Perception and Cognitive Performance in Healthy Adults.

Authors: Megan J. Kobel, Andrew R. Wagner, and Daniel M. Merfeld.

Past research has been able to identify an association between vestibular (i.e., inner ear) loss and changes in cognition. These associations have only focused on traditional vestibular assessments, which only assess reflexes without major contributions from the cortex. This study aimed to assess relationships between vestibular perception (i.e., how well we sense and feel motion) and various standard cognitive tests in healthy older adults. Overall, while no participants displayed clinically significant changes in cognition or motion perception, as motion perception abilities declined, suggesting declines in vestibular function, we saw co-occurring declines in cognitive function. These results suggest that measures of motion perception may capture aspects of brain health not captured on standard vestibular exams.

Vestibular Research Lab

Vestibular contributions to linear motion perception.

Authors: Megan J. Kobel, Andrew R. Wagner, and Daniel M. Merfeld.

Measures of motion perception reflect contributions from the vestibular system in the inner ear. For this study, we tested two adults with surgical removal of both inner ears on standard motion perception tasks to assess the extent that other sensory cues may contribute to motion perception despite experimental controls. Overall, we were able to identify that for linear motions (i.e., sliding side-to-side, up-down, or front-back) the vestibular system had major contributions to motion perception as the participants without inner ears had difficulty accurately performing these tasks. These decreases in performance were largest when the motions were up-and-down in the world and parallel to gravity, suggesting that these measures best capture vestibular contributions to motion perception.