# Biographical Sketch

Name: **Ananthanarayan (Ravi) A. Krishnan**
Present Rank and Title: Professor of Audiology/Hearing Science
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## BACKGROUND

### Academic Record

| Degree | Year | Institution | Major |
|---|---|---|---|
| Ph.D. | 1983 | University of Texas-Dallas | Hearing Science (Auditory Neuroscience) |
| M.S. | 1980 | University of Memphis | Audiology |
| B.Sc. | 1973 | University of Mysore-India | Speech & Hearing Sciences |

### Academic Appointments

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|---|---|---|
| 2009-present | Purdue University | Professor |
| 1998-2009 | Purdue University | Associate Professor |
| 1990-1998 | University of Tennessee | Assistant/Associate Professor |
| 1987-1989 | University of Pittsburgh | Assistant Professor |

### Clinical Experience

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|---|---|---|
| 1990-1998 | University of Tennessee | Electrophysiological assessment |
| 1985-1987 | Mercy Hospital, Chicago | Director of Evoked Potential Laboratory |

### Awards and Honors

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|---|---|
| 2021 | Elected Fellow of the American Speech Language Hearing Association |
| 2019 | SLHS Outstanding Graduate Instructor |
| 2016 | Career Research Achievement Award. College of Health and Human Sciences, Purdue University |
| 2013 | Visiting Researcher, Macquarie University, Australia |
| 2013 | Visiting Researcher, National Acoustics Laboratory, Australia |
| 2012 | Seed for Success Research Award, Purdue University (recognition for grant funding exceeding 1 million dollars) |
| 2011 | Visiting Research Scholar, National Acoustic Laboratory, Australia |
| 2010 | Visiting Research Scholar, University of Manchester, England |
| 2006 | Visiting Research Scholar, University of Lancaster, England |
| 1991 | Visiting Senior Lecturer, University of Sydney, Australia |
| 1987-88 | Young Investigator Award, ASHA Foundation |
| 1983-84 | Postdoctoral Fellowship, University of Wisconsin |
| 1984-85 | Postgraduate Researcher, University of California-Irvine |

### Membership in Professional Organizations

| | |
|---|---|
| 1990-present | Association for Research in Otolaryngology |
| 1988-present | American Academy of Audiology, Fellow |

1986-present American Speech Language Hearing Association
2008-present American Auditory Society

**Clinical Certification**
1984-present CCC-Audiology from the American Speech Language Hearing Association

## DISCOVERY

My current research relates to two distinct but related lines of research evaluating neural encoding of complex sounds at the cortical and subcortical levels: 1. Neural encoding of complex sounds in normal and impaired ears and electrophysiological evaluation of signal processing strategies in conventional hearing aids and cochlear implants; and 2. Neural encoding of pitch and how the hierarchical pitch processing networks are shaped by tonal language experience.

**1. Neural encoding of speech in normal and impaired ears:**

The long-term research objective is to evaluate the nature of neural representation of speech-like sounds in normal-hearing and hearing-impaired individuals in an effort to determine the perceptual consequences of degraded neural representation resulting from cochlear impairment and adverse listening conditions. Specific interest is in evaluating the relative roles of temporal envelop and temporal fine structure. To date our knowledge about neural representation of speech sounds is solely derived from animal experiments that are not readily applicable to humans. Thus, the human FFR provides for a noninvasive "window" into the physiological mechanisms underlying the processing of speech sounds in normal-hearing individuals and how hearing-impairment and adverse listening conditions could alter this mechanism. Knowledge about the characteristics of neural representation of speech in normal and hearing-impaired individuals may shed light on the acoustic features of speech sounds that are important in their identification and the nature of the degradation in representation of these features. Evaluation of several strategies to enhance acoustic features may provide us information about signal processing strategies that will optimally recover degraded representation that may be implemented in hearing prosthetic devices. The aim clearly is to develop an objective electrophysiologic index of the effectiveness of amplification strategies.

I am also interested in following a parallel translational research track evaluating functional changes consequent to sensorineural hearing loss, including hidden hearing loss, utilizing both the onset ABR components as well as the sustained frequency following responses. In order to tap at more caudal generators we are beginning to record responses using the TM electrode. The aim is to develop objective clinical measures to identify and characterize hearing losses of various etiologies in an effort to optimize management strategies. Another track of current research in my lab is aimed at determining stimulus manipulations that are sensitive to degradation in brainstem electrophysiologic measures in individuals with hidden hearing loss (cochlear

synaptopathy). The goal is to develop a reliable clinical measure to detect hidden hearing loss.

**2. <u>Experience-dependent plasticity for pitch representation in the brainstem</u>**

It is well established that neural processes underlying pitch at the cortical level are influenced by language experience. The question arises whether early, pre-attentive stages of pitch processing at both the brainstem and cortical levels may also be influenced by language experience. Indeed, our lab was the first to report that long-term language experience does influence pre-attentive stages of pitch processing at both the brainstem and cortical levels by enhancing the representation of linguistically relevant dimensions of pitch. Subsequent experiments have revealed that this experience dependent brainstem plasticity for pitch representation is: a) specific to pitch patterns that fall within the listeners' experience; b) not specific to a speech context; c) relatively more sensitive to rising versus falling curvilinear pitch contours; and d) particularly sensitive to the dynamic accelerating or decelerating portions of the pitch contours. These results suggest that neural mechanisms extracting pitch information at the brainstem level are sensitive to particular acoustic dimensions rather than speech per se. Evaluation of domain specificity (language vs. music) using pre-attentive cortical electrophysiological responses revealed that experience-dependent effects on pitch processing are domain-general and not driven by linguistic categories, which results in gradations of cortical plasticity with respect to linguistic pitch contours (native Chinese > English musicians > English non-musicians). We are currently evaluating the effects of domain specificity on brainstem responses to pitch patterns in order to determine whether graded sensitivity to pitch patterns as a function of one's learning experience is also evident at the level of the brainstem. The long term objective of this research program is to advance our knowledge of how pitch mechanisms in the auditory brainstem and at early sensory stages of processing in the auditory cortex reorganize with experience to enhance encoding of behaviorally relevant dimensions of sounds and to determine their role in the hierarchical processing of the temporal structure of sound. I am also interested in evaluating the nature of interplay between early sensory level processes and later cognitive level of processing. Specifically, if later cognitive level processing modulates early sensory level processing. The conventional wisdom is no longer tenable, i.e., that processing operations conducted in the relay nuclei of the brainstem and thalamus are general to all sounds, and that experience-dependent plasticity is not manifest until after the signal reaches the cerebral cortex. In speech perception, subcortical areas are not to be dismissed as 'auditory areas' and not relevant to language processing. Rather, early stages of processing along the auditory pathway may perform computations that reflect experience-dependent sensitivity to dimensions that are of linguistic relevance. A complete understanding of the neural organization of language can only be achieved by viewing language processes as a set of hierarchical computations between representations at different stages of processing.

Specific aims for the proposed research agenda for the next five years following along the above themes include:

1. Describe the nature of the correlation between cortical and BS representations of the experience-dependent pitch enhancement. Evidence for interactions between subcortical and cortical levels of processing for pitch, which would be expected from

the functional connectivity model. Will also shed light on relative roles of bottom up vs. top down modulation of the observed experience-dependent effects.
2. Relative susceptibility of experience-dependent speech encoding in adverse listening conditions (noise and reverberation) and competing (concurrent and spatial segregation) listening conditions.
3. Neural correlates of the relative contributions of temporal and spectral cues to lexical tone recognition.
4. The role of the corticofugal pathway (cortico-collicular) pathway in the top-down influence on the experience-dependent plasticity for pitch

**Publications**

**Journal Articles**

1. Suresh, C., & **Krishnan, A. (2022).** Frequency-following response to steady-state vowel in quiet and background nooise among marching band participants with normal hearing. *American Journal of Audiology*, 31, 719-736.
2. **Krishnan, A**., Gandour, J.T., & Suresh, C. **(2021).** Cortical hemisphere preference and brainstem ear asymmetryreflect experience-dependent functional modulation of pitch, *Brain & Language*, 221, October, 104995.
3. Suresh, C., & **Krishnan, A. (2021).** In search of a clinical measure to identify cochlear synaptopathy: Effects of stimulus level and background noise on the auditory brainstem evoked responses. *Ear & Hearing* 42,1, 53-67.
4. **Krishnan, A. (2020).** Neural representation of complex sounds in the human auditory brainstem. Perspective Article, *Journal of the All India Institute of Speech and Hearing,* 38, 1-22.
5. Suresh, C., **Krishnan, A**., & Luo, X. **(2020).** Human Frequency Following Responses to vocoded speech: Amplitude modulation versus amplitude plus frequency modulation. *Ear & Hearing,* 41,2, 300-311.
6. **Krishnan**, A., Suresh, C., & Gandour, J.T (**2019**). Tone language experience-dependent advantage in pitch representation in brainstem and auditory cortex is maintained under reverberation. *Hearing Research, 177, 63-71*.
7. Ananthakrishnan, S., & **Krishnan, A (2018).** Human frequency following responses to iterated rippled noise with positive and negative gain: Differential sensitivity to waveform envelope and temporal fine-structure. *Hearing Research, 367:113-123.*
8. Suresh, C., **Krishnan, A**., & Gandour, J.T. **(2017).** Language experience-dependent advantage in pitch representation in the auditory cortex is limited to favorable signal-to-noise ratios *Hearing Research, 355:42-53.*
9. **Krishnan, A., Suresh, C., &** Gandour, J.T. **(2017).** Differential sensitivity to changes in pitch acceleration in the auditory brainstem and cortex. *Brain & Language, 169:22-27.*
10. **Krishnan, A.,** Suresh, C., & Gandour J.T.. **(2017).** Changes in pitch height elicits both language universal and language dependent changes in neural representation of pitch in the brainstem and auditory cortex. *Neuroscience.* doi: http://dx.doi.org/10.1016/j.neuroscience.2017.01.01
11. Ananthakrishnan, S., Lou, Xin., & **Krishnan, A**. **(2017).** Human Frequency Following

Responses to Vocoded Speech. *Ear & Hearing,* 38(5):e256-e267, September/October.

12. **Krishnan, A.,** Gandour, J.T., Xu, Y., & Chandan, S. **(2016).** Language-dependent changes in pitch-relevant neural activity in the auditory cortex reflect differential weighting of temporal attributes of pitch contours. *Journal of Neurolinguistics*, 41:38-49
13. **Krishnan, A.,** Gandour, J.T., & Chandan, S. **(2016).** Language-experience plasticity in neural representation of changes in pitch salience. *Brain Research,* 1637: 102-117.
14. Gandour, J.T., & **Krishnan, A**. **(in press).** Neural Correlates of Tone Perception, A Window on Pitch Processing in the Brain. Brill's *Encyclopedia of Chinese Language and Linguistics*
15. Ananthakrishnan, S., **Krishnan, A.,** & Bartlett, E**. (2016).** Human frequency following response: Neural representation of envelope and temporal fine structure in listeners with normal hearing and sensorineural hearing loss. *Ear & Hearing, 37(2): e91-e103, Mar/Apr*
16. **Krishnan, A**., Gandour, J.T., Suresh, C. (**2015**). Experience-dependent enhancement of pitch-specific responses in the auditory cortex is limited to acceleration rates in normal voice range. *Neuroscience*, 303 (10): 433-455.
17. **Krishnan, A.,** Gandour, J.T., Suresh, C. **(2015).** Pitch processing of dynamic lexical tones in the auditory cortex is influenced by sensory and extrasensory processes. *European Journal of Neuroscience*. 41(11), 1496-1504.
18. **Krishnan, A**., Gandour, J.T., Ananthakrishnan, S., Venkatakrishnan, V. (**2015**). Language experience enhances early cortical pitch-dependent responses. *J. Neurolinguistics*, 33, 128-148.
19. **Krishnan, A.,** & Gandour, J.T. **(2014).** Language experience shapes processing of pitch relevant information in the human brainstem and auditory cortex: Electrophysiological evidence. *Acoustics Australia*, 42(3), 187-199.
20. **Krishnan, A**., Gandour J.T., & Suresh, C**. (2014)** Cortical pitch response components show differential sensitivity to native and nonnative pitch contours. *Brain & Language,* 138, 51-60.
21. **Krishnan, A**., Gandour, J.T., Ananthakrishnan, S., Venkatakrishnan, V. (**2014**). Cortical pitch response components index stimulus onset/offset and dynamic features of pitch contours. *Neuropsychologia, 59,* 1-12.
22. Bones, O., Hopkins, K., **Krishnan, A**., Plack, C.J. **(2014**). Phase locked neural activity in the human brainstem predicts preference for musical consonance. *Neuropsychologia, 58, 23-32.*
23. Gandour, J.T., & **Krishnan, A.** (**2014**). Neural bases of lexical tone. In H. Winskel & P. Padakannaya (Eds.), *South and Southeast Asian psycholinguistics* (pp. 339-349) Cambridge, UK: Cambridge University Press.
24. **Krishnan, A**;, Bidelman, G.M., Smalt, C.J., Ananthakrishnan, S., Gandour, J.T. (**2012**). Relationship between brainstem, cortical and behavioral measures relevant to pitch salience in humans. *Neuropsychologia*, 50, 2849-2859.
25. **Krishnan, A**., Gandour, J.T., & Bidelman, G.M. (**2012**). Experience-dependent plasticity in pitch encoding: from brainstem to auditory cortex. *NeuroReport, 23,* 498-502.
26. Smalt, C.J., **Krishnan, A**., Bidelman, G.M., Ananthakrishnan, S., & Gandour, J.T. (**2012**). Neural correlates of cochlear distortion products and their influence on representation of pitch relevant information in the human brainstem. *Hearing Research, 292,* 26-34.
27. Bidelman, G.M., Gandour, J.T., & **Krishnan, A.** (**2011**). Musicians demonstrate

experience-dependent brainstem enhancement of musical scale tones within continuously gliding pitch. *Neuroscience Letters*, *503*(3), 203-207.
28. **Krishnan, A**.,Gandour, J.T., Ananthakrishnan, S., Bidelman, G., & Smalt, C. **(2011).** Linguistic status of timbre influences pitch encoding in the brainstem. *NeuroReport*, 22, 801-803.
29. Bidleman, G; Gandour, J; & **Krishnan, A.** (**2011**). Musicians and tone-language speakers share enhanced brainstem encoding but not perceptual benefits for musical pitch. *Brain & Cognition, 77(1), 1-10.*
30. **Krishnan, A**.,Gandour, J.T., Ananthakrishnan, S., Bidelman, G., & Smalt, C. **(2011).** Functional ear (a)symmetry in brainstem neural activity relevant to encoding of voice pitch: A precursor for hemispheric specialization? *Brain and Language, 119, 226-231*.
31. Bidelman, G.M., **& Krishnan, A. (2011).** Brainstem correlates of behavioral and compositional preferences of musical harmony. *NeuroReport*, 22(5): 212-216.
32. **Krishnan, A**., & Plack, C. (**2011**). Neural encoding in the human brainstem relevant to the pitch of complex tones. *Hearing Research*, 275(1-2), 110-119.
33. Bidelman, G.M., **Krishnan, A**., Gandour, J. (**2011**). Enhanced brainstem encoding predicts musicians'perceptual advantages with pitch. *European Journal of Neuroscience.* 33: 530–538.
34. Bidelman, G.M., & **Krishnan, A**. (**2011**). Effects of reverberation on brainstem representation of speech in musicians and non-musicians. *Brain Research.*1355: 112-125.
35. Bidleman, G; Gandour, J; & **Krishnan, A.** (**2011**). Cross-domain effects of music and language experience on the representation of pitch in the human auditory brainstem. *J. Cog. Neuroscience.* 23:2:425-434.
36. **Krishnan, A**; Smalt, C; Bidelman, G.; Gandour, J. (**2010**). Language-dependent pitch encoding advantage in the brainstem is not limited to acceleration rates that occur in natural speech. *Brain and Language.* 114(3): 193-198.
37. **Krishnan, A**; Gandour, J; & Bidelman, G. (**2010**). Neural representation of pitch salience in the human brainstem revealed by psychophysical and electrophysiological indices *Hear. Res*. 268:60-66.
38. Gandour, J.T., **Krishnan, A**., & Bidelman, G.M. (**2010**). Neural substrates of lexical tone as revealed at different stages of cortical and subcortical processing. In L.H. Tan (Chair), C*ognitive neuroscience of language*, Pp 22-24. Symposium conducted at the 7th International Conference on Cognitive Science, Beijing, China.
39. Clinard, C; Tremblay, K; & **Krishnan, A.** (**2010**). Aging alters the perception and physiological representation of frequency: Evidence from human FFR recordings. *Hear. Res*. 264:48-55.
40. **Krishnan, A**; Gandour, J; & Bidelman, G. (**2010**). The effects of tone language experience on pitch processing in the brainstem . *J. Neurolinguistics*. 23:81-95.
41. **Krishnan,** A., & Agrawal, S. (**2010**). Human frequency-following response to speech-like sounds: correlates of off-frequency masking. *Journal of Audiology & Neuro-Otology*. 15:221-228.
42. **Krishnan, A**; Gandour, J; & Bidelman, G. (**2010**). Brainstem pitch representation in native speakers of Mandarin is less susceptible to degradation of stimulus temporal regularity. *Brain Res.* 1313, 124-133.
43. Chandrasekaran, B., Gandour, J.T., & **Krishnan, A.** (**2009**). Neuroplasticity in the

preattentive processing of linguistic pitch: Evidence from cross-language and cross-domain studies. *Festschrift in linguistics, applied linguistics, language and literature in honor of Prof. Dr. Udom Warotamasikkhadit* (pp. 68-86). Bangkok: Saha Thammik.

44. Bidelman, G; & **Krishnan, A.** (**2009**). Neural correlates of consonance, dissonance, and the hierarchy of musical pitch in the human brainstem. *J. Neuroscience.* 29(42):13165–13171.
45. Chandrasekaran, B., **Krishnan**, A., & Gandour, J.T. (**2009**). Sensory versus phonetic processing of linguistic pitch as reflected by the mismatch negativity. *Ear and Hearing*. 30(5):552-558.
46. **Krishnan**, A., & Gandour, J.T. (**2009**). The role of the auditory brainstem in processing linguistically-relevant pitch patterns. *Brain and Language*. 110:135-148.
47. Madhavi, B., **Krishnan**, A., & Weber-Fox, C. (**2009**). Brainstem correlates of temporal auditory processing in children with specific language impairment. *Developmental NeuroScience.*
48. **Krishnan**, A., Swaminathan, J., & Gandour, J.T. (**2009**). Experience-dependent enhancement of pitch representation in the brainstem is not specific to speech context. *Journal of Cognitive Neuroscience.* 21(6):1092-1105.
49. **Krishnan**, A., Gandour, J.T., Bidelman, G.M., & Swaminathan, J. (**2009**). Experience dependent neural representation of dynamic pitch in the brainstem. *Neuroreport,* 20:400-413.
50. Chandrasekaran, B., **Krishnan**, A., & Gandour, J.T. (**2009**). Relative influence of musical and linguistic experience on early cortical processing of pitch contours. *Brain and Language*. 108
51. Swaminathan, J., **Krishnan**, A., & Gandour, J.T. (**2008**). Pitch encoding in speech and nonspeech contexts in the human auditory brainstem. *Neuroreport, 19*(11),1163-1167.
52. **Krishnan,** A., & Plack, C. (**2009**). Auditory brainstem correlates of basilar membrane nonlinearity. *Journal of Audiology and Neuro-Otology.*14: 88-97.
53. Elsisy, H., & **Krishnan**, A. (**2008**). Comparison of response characteristics of acoustical and neural distortion product at 2f1-f2 in normal hearing adults. *International Journal of Audiology*, *47*, 431-438.
54. Lucas, J. R., Freeberg, T. M., Long, G. R. and **Krishnan, A**. (**2007**). Seasonal variation in avian auditory evoked responses to tones: a comparative analysis of Carolina chickadees, tufted titmice, and white-breasted nuthatches. *J Comp Physiol A Neuroethol Sens Neural Behav Physiol* 193: 201-215.
55. Swaminathan, J., **Krishnan**, A., & Gandour, J.T. (**2007**). Applications of static and dynamic iterated rippled noise to evaluate pitch encoding in the human auditory brainstem. *IEEE Transactions on Biomedical Engineering*, *55*(1), 271-287.
56. Chandrasekaran, B., Gandour, J.T., & **Krishnan,** A. (**2007**). Neuroplasticity in the processing of pitch dimensions: A multidimensional scaling analysis of the mismatch negativity. *Restorative Neurology and Neuroscience, 25*(3/40),195-210.
57. Chandrasekaran, B., **Krishnan,** A.**,** & Gandour, J.T. (**2007**). Experience-dependent neural plasticity is sensitive to shape of pitch contours. *Neuroreport. 18*(18), 1963-1967.
58. Lucas, J.R., Freebereg,T.M., Long, G.R., & **Krishnan,** A. (**2007**). Seasonal variation inavian auditory evoked responses to tones: a comparative analysis of Carolina chickadees, tufted titmice, and white-breasted nuthatches. *Journal of Comparative Physiol*ogy, *193*(2), 201-215.

59. Chandrasekaran, B., **Krishnan,** A., & Gandour, J.T. (**2007**). Mismatch negativity to pitch contours is influenced by language experience. *Brain Research, 1128*(1), 148-156.
60. Xu, Y., **Krishnan,** A., & Gandour, J.T. (**2006**). Specificity of experience-dependent pitch representation in the brainstem. *Neuroreport, 17*(15),1601-1605.
61. Ranaweera, RD., Talavage, TM., & **Krishnan, A.** (**2005**). Features differentiate direction of finger movement in cued and self-paced tasks. Proceedings of the 2 International *IEEE EMBS* Conference on Neural Engineering, Arlington, Virginia, 151-154.
62. **Krishnan,** A., Xu, Y., Gandour, J.T., & Cariani, P. (**2005**). Encoding of pitch in the human brainstem is sensitive to language experience**.** *Cognitive Brain Research, 25*,161-168.
63. Wilson, J., & **Krishnan,** A. (**2005**). Human frequency following response to stimuli producing masking level difference. *Journal of the American Academy of Audiology, 16*,184-195.
64. Pandya, P.P., & **Krishnan,** A. (**2004**). Human frequency following response correlates of distortion product at 2f1-f2. *Journal of the American Academy of Audiology, 15*,184-197.
65. **Krishnan,** A., Xu, Y., Gandour, J.T., & Cariani, P. (2004). Human frequency following response: representation of pitch contours in chinese tones. *Hearing Research, 189*,1-12.
66. **Krishnan,** A. (2002). Human frequency following response: Representation of steady-state vowels. Hearing Research, 166,192-201.
67. Freeberg, T.M., Lucas, J.R., **Krishnan,** A., & Long, G. (2002). A Comparative study of avian auditory brainstem responses: correlations with phylogeny and vocal complexity, and seasonal effects. *Journal of Comparative Physiol*ogy, *188*,981-992.
68. Plyler, P., & **Krishnan,** A. (2001). Human frequency following response: Representation of CV formant transitions in normal-hearing and hearing-impaired listeners. *Journal of the American Academy of Audiology*, *12*,523-533.
69. **Krishnan,** A., & Parkinson, J. (2000). Human frequency following response: Representation of tonal sweeps. *Journal of Audiology & Neuro-Otol*ogy, *5*,312-321.
70. **Krishnan,** A. (1999). Human frequency following responses to two-tone approximations of steady-state vowels. *Journal of Audiology and Neuro-Otology*, *4*, 95-103.
71. **Krishnan,** A., & McDaniel, S. (1998). Binaural interaction in the human frequency following response: Effects of interaural intensity difference. *Journal of Audiology and Neuro-Otology, 3*, 291-299.
72. **Krishnan,** A., & Durrant, J.J. (1994). Comparison of transducer radiation in a deaf subject and a resistor-network simulator. *British Journal of Audiol*ogy, *28*, 149-154.
73. **Krishnan,** A., & Durrant, J.J. (1992). The frequency following response and the onset response: Evaluation of frequency specificity using a forward-masking paradigm. *Ear & Hearing, 13*(4), 228-232.
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75. **Krishnan,** A., & Durrant, J.J. (1991). On the origin of wave II of the auditory brainstem responses. *Ear & Hearing*, *12*(3), 174-179.
76. **Krishnan,** A., & Gerken, G.M. (1987). Response enhancement and reduction of the ABR in a forward-masking paradigm. *Electroencephalography & Clinical Neurophysiology, 66*, 427-439.
77. **Krishnan,** A., & Gerken, G.M. (1983). Post-Stimulatory effects on the auditory brainstem response: Partial masking and enhancement. *Electroencephalography &*

*Clinical Neurophysiology, 55*(2), 223-226.

**Book**

**Krishnan, A. (Ed) (2021). Auditory Brainstem Evoked Potentials: *Clinical and Research Applications. In Press. Plural Publishing Inc. San Diego, CA*. *Planned Fall 2021*.**

**Book Chapters**

**Krishnan, A.,** & Gandour, J. T. (2016). Brainstem representation of pitch relevant information is shaped by language experience. In: *The Frequency-following Response: A Window into Human Communication* (Chapter 3, 45-73. Eds Kraus, N., Anderson, S., White-Schwoch. T., Popper, A.N., Fay, R.R. Auditory Research Series, ASA Press, Springer

Gandour J.T., & **Krishnan, A.** (2015). Tonal language processing. In: Eds. Hickok, G. & Small, S.L. (Eds). *Neurobiology of Language* (Chapter 87, 1095-1107). Boston: *Academic Press.*

**Krishnan**, A. (2006). Human frequency following response. In: RF Burkard, M. Don, JJ Eggermont (Eds.), *Auditory evoked potentials: Basic principles and clinical application* (pp. 313-335). Baltimore: Lippincott Williams & Wilkins.

Moore, E.J., & **Krishnan**, A. (1983). Effects of ipsilateral and contralateral masking on the auditory brainstem responses. In: Moore EJ (Ed.), *Bases of auditory brain-stem evoked responses* (pp. 240-251). New York: Grune and Stratton.

**Conference Proceedings**

**Krishnan**, A. (1994). Human frequency following responses to synthetic speech stimuli. In: *Proceedings of the International Cochlear Implants, Speech and Hearing Symposium*, Melbourne. Vol 6, 7-8.

**Krishnan,** A., Gandour, J.T., & Swaminathan, J (2008). Influence of language experience on pitch representation in the human brainstem. *Interspeech 2008*, Brisbane, Australia.

**Presentations: International**

**Krishnan, A.** (July, 2010). Influence of language and music experience on neural encoding of pitch in the human brainstem. Invited presentation, Department of Physiology, Cambridge University, England.

**Krishnan, A.** (July, 2010). Experience-dependent plasticity for pitch encoding in the human brainstem. Invited presentation, Department of Audiology, Manchester University, England.

**Krishnan, A**. (Sep, 2008). Experience dependent plasticity in pitch representation in the human brainstem. Invited speaker, Special Session: Cross-linguistic and developmental issues in the perception and production of lexical tone. InterSpeech 2008, Brisbane, Australia.

Chandrasekaran, B., **Krishnan, A.**, & Gandour, J.T. (Dec, 2006). Language-experience modulates preattentive pitch processing: A crosslanguage study. Fourth Conference on Mismatch Negativity (MMN) and its Clinical and Scientific Applications, Cambridge, UK.

**Krishnan, A.,** & Agrawal, S. (Jul, 2001). Human frequency following response correlates of upward spread of masking. Evoked Potential Study Group Meeting, Vancouver.

**Krishnan, A.,** & Chelluri, M. (Jul, 2001). Human frequency following response: Multiple

generators may increase upper frequency limit. Evoked Potential Study Group Meeting, Vancouver.

**Krishnan, A.** (Jul, 2001). Human frequency following response correlates of pitch. Evoked Potential Study Group Meeting, Vancouver.

**Krishnan, A.** (Jul, 1996). Representation of speech-like sounds in the human frequency following response. Auditory Basis of Speech Perception, Keele University, England.

**Krishnan, A.** (May, 1995). Human electrophysiologic correlates of lateralization. Evoked Potential Study Group Meeting, Lyon, France.

**Krishnan, A.** (Oct, 1994). Human frequency following responses to synthetic speech stimuli. International Cochlear Implants, Speech and Hearing Symposium, Melbourne.

**Presentations: National**

Klinker, M., Krishnan, L.A., **Krishnan, A. (2018)**. Neural representation of speech in individuals with different noise tolerances. Poster presented at the mid-winter meeting of the American Auditory Society, Scottsdale, Arizona, March 2018.

Ackerman, R., Krishnan, L.A., Suresh, C.H., **Krishnan, A. (2018).** Hidden hearing loss: Is music noise to ears? Poster presented at the mid-winter meeting of the American Auditory Society, Scottsdale, Arizona, March 2018.

**Krishnan, A.,** Gandour, J.T., Suresh, C.H. (2018). Language experience-dependent advantage in cortical pitch representation is maintained under reverberation. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2018, San Diego.

Suresh, C.H., **Krishnan, A. (2018).** Search for electrophysiological indices of hidden hearing Loss. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2018, San Diego.

**Krishnan, A**., Gandour, J., & Chandan, S. (**2015**). Influence of sensory and extrasensory processes on pitch processing in the auditory cortex. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2015, Baltimore.

**Krishnan, A**., Gandour, J., & Chandan, S (**2015**). Experience-dependent enhancement of pitch-specific responses in the auditory cortex is limited to acceleration rates in normal voice range**.** Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2015, Baltimore.

**Krishnan, A**., Gandour, J., Ananthakrishnan, S. & Vijayaraghavan, V. (**2014**). Cortical pitch response components mark multiple attributes of pitch contours. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2014, San Diego.

Ananthakrishnan, S., & **Krishnan, A.** (**2014**). Effects of adverse listening conditions on subcortical neural representation of speech sounds in normal and impaired ears. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2014, San Diego.

Wendel, J., **Krishnan, A**. & Alexander, A. (**2014**). Effects of frequency compression on the neural encoding of complex sounds in the human brainstem. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2014, San Diego.

Ananthakrishnan, S. **Krishnan, A.** (**2013**). Subcortical pitch encoding of speech sounds in the

normal and impaired auditory systems. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2013, Baltimore

**Krishnan, A**., Ananthakrishnan, S., & Gandour, J.T. (**2013**). Cortical pitch response: differential sensitivity to pitch contour and pitch direction. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2013, Baltimore

Ananthakrishnan, S; **Krishnan, A**; Smalt, C.J. & Bidelman, G. (**2012**). Brainstem neural encoding of envelope and temporal fine structure of complex stimuli in normal and impaired Ears. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2012, San Diego.

Smalt, C.J., **Krishnan, A** & Talavage, T.M. (**2012**). A subtraction method to reduce cochlear implant electrical artifact contamination of sustained auditory brainstem responses. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2012, San Diego.

**Krishnan**, A., Smalt, C.J., Bidelman, G., Ananthakrishnan, S. & Gandour, J.T. (**2012**). Evaluation of pitch representations measured concurrently in auditory brainstem and cortex, and their relationship to behavioral measures of pitch salience. Poster presented at the Mid-Winter research meeting of the Association for Research in Otolaryngology, February 2012, San Diego.

**Krishnan, A**., Gandour, J., Ananthakrishnan, S., Bidelman, G., Smalt, C. (Feb, 2011). Functional ear (a)symmetry in brainstem neural activity relevant to encoding of voice pitch: A precursor for hemispheric specialization? Mid-winter meeting of the Association for Research in Otolaryngology (ARO), Baltimore.

**Krishnan, A.,** & Plack, C. (Feb, 2011). Human frequency following responses: Correlates of the pitch of complex stimuli with inharmonic and frequency-shifted components**.** Mid-winter meeting of the Association for Research in Otolaryngology (ARO), Baltimore.

**Krishnan, A**., & Smalt, C. (Feb, 2011). Experience dependent enhancement of pitch encoding in the brainstem: resolved versus unresolved components. Mid-winter meeting of the Association for Research in Otolaryngology (ARO), Baltimore.

Bidelman, G., Gandour, J.T., & **Krishnan, A.** (Feb, 2011). Enhanced brainstem pitch encoding in tone-language speakers does not translate to perceptual benefits for music. Mid-winter meeting of the Association for Research in Otolaryngology (ARO), Baltimore.

**Krishnan, A.**, Ananthakrishnan, S., Bidelman, G. (Feb, 2010). Human frequency following responses: Differential responses to positive and negative gain of iterated rippled noise. Mid-winter meeting of the Association for Research in Otolaryngology (ARO), Los Angeles.

**Krishnan, A**., Smalt, C., Gandour, J. (Feb, 2010). Experience-dependent plasticity for pitch extends beyond normal pitch range in natural speech. Mid-winter meeting of the Association for Research in Otolaryngology (ARO), Los Angeles.

Chandrasekaran, B., **Krishnan, A**., & Gandour, J.T. (Feb, 2008). Influence of musical and linguistic experience on early cortical processing of pitch contours. Association for Research in Otolaryngology (ARO) Meeting, Phoenix.

**Krishnan, A.,** & Plack, C. (Feb, 2008). Neural representation of pitch in the human brainstem: Sine vs. alternating phase stimuli. ARO Meeting, Phoenix.

**Krishnan, A.,** & Ganesh, K. (Feb, 2008). Human frequency following responses to sinusoidally amplitude modulated tones. ARO meeting, Phoenix.

Hampton, A., **Krishnan, A.,** & Weber-Fox, C. (Feb, 2008). Frequency following responses in adults who stutter. ARO Meeting, Phoenix.

Swaminathan, J., **Krishnan, A.,** & Gandour J.T. (Feb, 2008). Experience dependent enhancement of pitch is not speech specific. ARO meeting, Phoenix.

**Krishnan, A.,** & Plack, C. (Feb, 2007). An electrophysiological measure of basilar membrane nonlinearity in humans. ARO Meeting, Denver.

**Krishnan, A.,** Swaminathan, J., & Gandour J.T. (Feb, 2007). Effects of positive and negative gain on the encoding of pitch using iterated rippled noise. ARO Meeting, Denver.

**Krishnan, A.,** Swaminathan, J & Gandour J.T. (Feb, 2006). Pitch encoding of dynamic iterated rippled noise in the human brainstem is sensitive to language experience. ARO Meeting, Baltimore.

**Krishnan, A.,** & Ganesh,V. (Feb, 2006). Electrophysiological correlates of the distortion product at 2f1-f2 to tonal sweeps. ARO Meeting, Baltimore.

Chandrasekaran, B., **Krishnan, A.,** & Gandour J.T. (Feb, 2006) Influence of language experience on the pitch representation of Chinese lexical tones at the cortical level. ARO Meeting, Baltimore.

**Krishnan, A.,** Xu, Y., Gandour J.T., & Cariani, P. (Feb, 2005). Human frequency following response: Language experience may influence pitch encoding at the brainstem level. ARO Meeting, Baltimore.

**Krishnan, A.,** Xu, Y., Gandour, J.T., & Cariani, P. (Feb, 2004). Human frequency following response: Representation of pitch contours in Chinese tones. ARO Meeting, New Orleans.

**Krishnan, A.,** & Payal, A. (Feb, 2004). Auditory brainstem response: relative contributions of excitatory spread and suppression to masking. ARO Meeting, New Orleans.

**Krishnan, A**., & Elsisy, H. (Feb, 2003). Human frequency following response: Evaluation of the distortion product at 2f1-f2. ARO Meeting, Daytona Beach.

**Krishnan, A.,** & Chelluri, M. (Feb, 2003). Human frequency following responses to tonal sweeps in normal children and children with specific language impairment. ARO Meeting, Daytona Beach.

**Krishnan, A.,** & Wilson, J. (Feb, 2003). Human frequency following responses to masking level difference stimuli. ARO Meeting, Daytona Beach.

Neel A.T., **Krishnan, A.,** & Collins, K. (May, 2001). Use of formant movement detail in vowel identification. Acoustical Society of America Meeting. St. Louis.

**Krishnan, A. (**Feb, 2001). Human frequency following response: Representation of voice pitch. ARO Meeting, St. Petersburg Beach.

Freeberg, T., Lucas, J., **Krishnan, A.,** & Long, G. (May, 2000). Comparative study of avian auditory brainstem evoked responses. Animal Behavior Society Meeting, Miami.

**Krishnan, A.,** & Parkinson J. (Feb, 1998). Human frequency following response: Neural encoding of time-variant frequency. ARO Meeting, St. Petersburg Beach.

**Krishnan, A.,** & Pandya P. (Feb, 1997). Human frequency following response correlates of distortion product (2f1-f2). ARO Meeting, St. Petersburg Beach.

**Krishnan, A.** (Feb, 1995). Human frequency following responses to two-tone approximations of vowels. ARO Meeting, St. Petersburg Beach.

**Krishnan, A.,** & McDaniel S. (Feb, 1995). Human frequency following response correlates of lateralization: Interaural intensity difference. ARO Meeting, St. Petersburg Beach.

**Invited Lectures**

**Krishnan, A.** (January 2020). Experience-dependent neural organization for pitch processing in the auditory cortex: Electrophyiologic and fMRI measures. Sri Ramachandra Institute of Speech and Hearing, Bangalore, India.

**Krishnan, A.** (January 2020). Experience-dependent neural organization for pitch processing in the auditory brainstem and cortex. Department of Audiology, National Institute of Mental Health and Neurosciences, Bangalore, India.

**Krishnan, A.** (January 2018). Neural correlates of pitch processing in the brainstem. National Institute of Speech and Hearing, Trivandrum, India

**Krishnan, A.** (March 2015). Language experience shapes pitch processing in the auditory brainstem and cortex. Speech Language Hearing Sciences, Arizona Stata University, Tempe, Arizona

**Krishnan, A.** (January 2015). Sensory and extrasensory processes influence pitch processing in the auditory cortex. Brain Initiative, University of Florida, Gainesville, Florida

**Krishnan, A.** (November, 2014)**.** Neural representation of complex sounds in the human brainstem. Annual meeting of the American Speech Language and Hearing Association, Orlando, Florida.

**Krishnan, A.** (March, 2014). Neural representation of pitch relevant activity in the brainstem. Beijing Ear Institute, Capitol University of Beijing. Conference on Neural representation of complex sounds. Beijing, China.

**Krishnan, A** (May, 2014). Language experience shapes pitch processing in the human brainstem. Frequency Following Response Workshop, University College London, London, UK.

**Krishnan, A** (March, 2014). Experience-dependent plasticity for pitch processing in the brainstem and auditory cortex. Behavioral Neurosciecne, University of Texas-Dallas.

**Krishnan, A** (January, 2014). Pitch processing in the brainstem is shaped by experience. Department of Otolaryngology, Stanford University, Palo Alto, California.

**Krishnan, A** (May, 2013). Influence of language experience on the neural encoding of pitch at cortical and subcortical levels. ARC Center of Cognition and its Disorders, Macquarie University, Sydney, Australia

**Krishnan, A,** (July 2011). Invited to head the panel on Auditory Neuroscience for Symposium on "Exploring areas of Research in Cognitive Sciences" . at the All India Institute of Speech and Hearing, Mysore, India

**Krishnan, A.** (October, 2010). Influence of language experience on pitch encoding in the human brainstem, Department of Lingusitics, Macquarie University, Sydney, Australia.

**Krishnan, A.** (October, 2010). Neural mechanisms underlying enhancement of experience-dependent pitch encoding in the human brainstem, National Acoustics Laboratory, Sydney, Australia.

**Krishnan, A.** (July, 2010). Influence of language experience on pitch encoding in the human brainstem, Department of Physiology, Cambridge University, England.

**Krishnan, A.** (July, 2010). Influence of language experience on pitch encoding in the human brainstem, Department of Psychology, Manchester University, England.

**Krishnan, A.** (Jun, 2008). Dimensions of language-experience dependent plasticity for pitch in the human brainstem. Distinguished Lecture Series, Northwestern University, Evanston.

**Krishnan, A**. (Jun, 2008). Frequency and place specificity of the auditory brainstem responses.

AuD Seminar, Northwestern University, Evanston.

**Krishnan, A**. (Jun, 2006). Influence of language experience on the representation of pitch in the human brainstem. Department of Psychology, Lancaster University, Lancaster, UK.

**Krishnan, A.** (Jun, 1999). Representation of speech-like sounds in the human frequency following response. Department of Physiology, University of Auckland, New Zealand.

**Krishnan, A.** (Jun, 1999). Representation of speech-like sounds in the human frequency following response. Department of Physiology, University of Western Australia, Perth.

**Involvement in the Graduate Research Program**

**Ph.D.**

Major Professor; Aditi Gargeshwari (current), Raghav Jha (current); Chandan Suresh (2018); Ananthakrishnan, (2014); Chris Smalt (2013), Gavin Bidelman (2011); Chandrasekaran (2008); Xu (2005); Elsisy (2005); Chelluri (2004); Plyler (1998).
Committee Member: 3, SLHS; 3, BME; 2, ECE; 2, BIOSCI (current); Dhar (01)

**M.S.**

Major Professor: 12 completed since ‘98
Committee Member: 3 completed since ‘98

**AuD**

Major Professor: 4 since ’98; 2 current students

NIH postdoctoral fellow, Freeberg, T., 1999-2002. Assisted in the development of research protocols and in data collection and interpretation for a comparative study of avian auditory brainstem evoked responses.

NIH Training Grant, Bidelman, G., 2008-2009. Research aimed at evaluating the processing of pitch of musical stimuli in the human brainstem in musicians and non-musicians.

**Involvement in Department and University wide Academic Committees**

**Department**

| | |
|---|---|
| 2016- | Member, Audology exam committee |
| 2016- | Audiology Curriculum Committee |
| 2015- | Graduate Program-Audiology/Hearing Science Curriculum Committee |
| 2010-2014 | Member, SLHS new building committee |
| 2009-2013 | Doctoral program curriculum committee |
| 2007-08 | Undergraduate Curriculum; Graduate Committee (Chair); Faculty Search |
| 2006-07 | Undergraduate Curriculum |
| 2004-05 | Faculty Search (Audiology); MS Comps |
| 2003-04 | MS Comps; Brown Bag Seminar (Coordinator) |
| 2001-02 | MS Comps, Chair; AuD Planning; Faculty Search (Audiology) |
| 2000-01 | AuD Planning; MS Comps |
| 1999-00 | Audiology Curriculum, Chair; MS Comps; Faculty search (Audiology) |
| 1998- | Faculty Advisor, Coach/Player, Purdue University Cricket Club |
| 1998-99 | AuD Curriculum, Chair; Graduate Committee |

**College of Human and Health Sciences**

2015-2018 Member: College of Health and Human Sciences (HHS): Research Advisory Committee
2017- Member, Ad Hoc Committee on Institutional Review Board
2010- Member: College of Health and Human Sciences (HHS) Taskforce for Global Strategic Partner Program
2010- Member: HHS International Academic Exchange Programs
2005-2010 Senator: University Senate
2004-2008 Member, Biomedical IRB
2000-2005 Senate Department of Speech Language Hearing Sciences

**Service at National Level**

Section Editor (2010-present): Ear & Hearing, American Auditory Society
Editorial Board member (2010-present): Ear & Hearing , American Auditory Society
Member (2014-2017): Scientific and Professional Education Board, American Speech Language Hearing Association
Chair, Hearing and Vestibular Science Section, ASHA 2017
Chair, ASHA Symposium on Hearing, ASHA 2017
Member (2018-present): ASHA mentor program for junior faculty
Grant reviewer (2017-2019): graduate student grants, ASHA

**Research Grants**

**Extramural**

2018: Influence of language experience on subcortical and early cortical representation of pitch.
Role: PI
Agency: NIH-NIDCD
Type : RO1 DC 008549-01A1 competitive renewal
Duration: 5 Years (9/1/2020- 9/31/2025)
Status: to be submitted August 2020
Budget: 2.7 million dollars

2011: Influence of language experience on subcortical and early cortical representation of pitch.
Role: PI
Agency: NIH-NIDCD
Type : RO1 DC 008549-01A1
Duration: 5 Years (4/1/2012- 3/31/2017)
Status: currently on no cost extension
Budget: 1.8 million dollars

2007-2011: Language-dependent plasticity in the encoding of pitch in the human brainstem.
Role: PI
Agency: NIH-NIDCD
Type : RO1 DC 008549-01A1

Duration: 4 Years (9/1/2007- 8/31/2011) with one year extension
Status: Funded: $870,000

1999: Neural representation of speech-like sounds in normal hearing and hearing-impaired subjects, National Organization for Hearing Research, PI, $10,000

1998: Auditory evoked potential correlates of auditory stream segregation. National Organization for Hearing Research, PI, $10,000

1993: Neural encoding of speech in the human brainstem
Role: PI
Agency: NIH-NIDCD
Type: RO3 DC 01980-02
Duration: 2 Years (1993-1995)
Funded: $230,000

**Intramural**

**2019-2021:** Influence of language experience on pitch processing at the cortical and subcortical levels. NIH R01 competitive renewal grant program, Office of Research, Purdue University, $30,000

2008 Research Incentive Grant, $1000
2007 Research Incentive Grant, $1000
2006 Research Incentive Grant, $1000
2005-06 Instructional Technology Grant, PI, $20,000

**Other Evidence of National and International Recognition**

Section Editor, Auditory Neuroscience-Central, Ear and Hearing (2010-present)
Member, Scientific and Professional Education Board, American Speech Language Hearing Association (2014-2017)
Chair, Hearing and Vestibular Science Section, ASHA 2017
Chair, ASHA Symposium on Hearing, ASHA 2017

**External Examiner (PhD dissertation)**

Universiyt of Toronto, Rotman Research Institute, October 2014
University of Mysore, India, Department of Audiology/Hearing Science (January 2009)
University of Mysore, India, Department of Audiology/Hearing Science (Jan, 2008)
University of Toronto, Rotman Research Institute (Apr, 2008)
University of Washington, Department of Speech Language Hearing Sciences, (Dec, 2008)
University of Mysore, India, Department of Audiology/ Hearing Science (May 2009)

**Editorial Consultant (2000-present)**

*Hearing Research; Journal of Acoustical Society of America; IEEE Biomedical Transactions; International Journal of Audiology; Audiology & Neurootology; Ear and Hearing; JSHLR; Developmental Science; Journal of Cognitive Neuroscience; and Journal of Research in Otolaryngology;Cerebral Cortex; NeuroImage,*

**Grant reviewer**

NSF (2001); NIH (2008)