BIOGRAPHICAL SKETCH

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NAME: Lutfi, Robert A.

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POSITION TITLE: Professor, Department of Communication Sciences and Disorders

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of South Florida, Tampa, FL	BA	1975	Experimental Psychol.
University of South Florida, Tampa, FL	MA	1977	Experimental Psychol.
Loyola University of Chicago, Chicago, IL	Ph.D.	1980	Experimental Psychol.
MRC Applied Psychology Unit, Cambridge, ENG	Post Doc	1980	Psychoacoustics
Northwestern University, Evanston, IL	Post Doc	1981-1983	Psychoacoustics

A. Personal Statement

My area of expertise is auditory psychophysics. I completed my dissertation under the supervision of Dr. William A. Yost, and received postdoctoral training in the laboratories of Drs. Fred L. Wightman, Roy Patterson and David M. Green. Since receiving my Ph.D., I have been fascinated by the question of how our ability to detect and identify complex sounds in noise is influenced by both lawful and random variation in sound as occurs in nature, and how this ability is affected by hearing loss. A goal of my research has been to develop computational models for predicting detection and identification performance under noisy conditions that approximate those we encounter in everyday listening. I have published over 70 papers in peer-reviewed scientific journals and several book chapters directly or indirectly related to this topic. My research programs have been supported by grants from the National Science Foundation, the Deafness Research Foundation, the Air Force Office of Scientific Research, the Office of Naval Research, the National Institute of Deafness and Communicative Disorders, and the National Institute for Child Health and Human Development. My current NIDCD-funded research program builds on 38 years of my work on problems of auditory detection and identification in noise in normal-hearing adults, children and the hard-of-hearing.

B. Positions and Honors

Positions and Employment

1977-1979 Lecturer, Psychology Department, Loyola University of Chicago
1979-1980 Visiting Assistant Professor of Psychology, Psychology Department, Indiana University, Bloomington
1983-1984 Research Scientist, Central Institute for the Deaf, Washington University, Saint Louis, MO
1984-1989 Associate Scientist, Waisman Center, University of Wisconsin–Madison
1986 Lecturer, Department of Communicative Disorders, University of Wisconsin–Madison
1987-1989 Adjunct Professor of Psychology, Department of Psychology, University of Florida, Gainesville
1989-1992 Assistant Professor of Audiology, Department of Communicative Disorders, University of Wisconsin–Madison
1992-1996 Associate Professor of Audiology, Department of Communicative Disorders, University of Wisconsin–Madison
1993-1996 Associate Professor of Psychology, Department of Psychology, Univ. of Wisconsin–Madison

1996-2017	Professor of Audiology, Department of Communication Sciences and Disorders, University of Wisconsin–Madison
1996-2017	Professor of Psychology, Department of Psychology, University of Wisconsin–Madison
2006	Chair, Department of Communicative Disorders, University of Wisconsin–Madison
2017-present	Professor of Audiology, Department of Communication Sciences and Disorders, University of South Florida, Tampa

Other Professional Activities and Honors

- Ad hoc reviewer for the National Science Foundation
- Ad hoc reviewer for the National Institutes of Deafness and Communicative Disorders
- Ad hoc reviewer for Israel Science Foundation
- Ad hoc reviewer for National Energy Systems, Air Force Office of Scientific Research
- Ad hoc reviewer for United States Civilian Research and Development Foundation
- Consultant on various NSF and NIH Grants
- Editorial Consultant for the *Journal of the Acoustical Society of America*, *Journal of Experimental Psychology, Perception and Psychophysics*, and *IEEE Transactions on Audio, Speech and Language Processing*
- Fellow, Acoustical Society of America
- Former Member of Committee on Psychological and Physiological Acoustics, Acoustical Society of America
- Member of the American Statistical Association
- Former Member Executive Committee, Psychological Acoustics, Acoustical Society of America
- Former Member Technical Committee, Psychological Acoustics, Acoustical Society of America
- University of Wisconsin, Faculty Senate (1990-1995)
- Associate Editor, Physiological and Psychological Acoustics, *Journal of the Acoustical Society of America* (2004-2007)
- Member of Social and Behavioral Science Internal Review Board, Univ. Wisconsin–Madison (2006-2007)
- Associate Editor, *Journal of Speech, Language and Hearing Research* (2011)
- Member Laboratory Assessments Board, National Academy of Sciences, Human Factors Science at the Army Research Lab (2012-2014)
- Member Intelligence Science and Technology Experts Group, National Academies of Sciences, Engineering and Medicine (2015-present)
- Member of Screening Panel for the Flame Challenge International Science Competition, hosted by the Alan Alda Center for Communicating Science at Stony Brook University

C. Contributions to Science

1. One unavoidable conclusion to be drawn from decades of research on hearing is that real differences remain after training in the ability of normal-hearing listeners to perform complex auditory tasks. Nowhere is this more evident than in studies of 'cocktail-party listening' - a metaphor for everyday listening where multiple sound sources compete for one's attention. Until recently, such differences among normal-hearing listeners were attributed mostly to deficits in non-auditory processes; working memory, selective attention or cognition. This view is now changing. In the past decade, evidence has accumulated from animal studies for a cochlear synaptopathy that is undetected by standard audiometric evaluation and that specifically affects one's ability to listen in a background of noise [Kujawa and Liberman (2009). J. Neurosci. 29, 14077–14085]. It has been suggested that the pathology may be widespread in the population and responsible for the large individual differences observed in the ability of otherwise normal-hearing individuals to listen in noise. Our most recent work provides behavioral data consistent with this view. The evidence is based on an analysis of the types of errors that are predictive of differences in the performance observed among individuals in cocktail-party listening tasks.

    a. Lutfi, R.A., Tan, A. and Lee J. (2018). Modeling individual differences in cocktail-party listening, International Symposium of Hearing, invited paper to appear in special issue of Acta Acoustica.
    b. Lutfi, R.A., Tan, A. and Lee J. (2017). Individual differences in cocktail party listening: The relative role of decision weights and internal noise. J. Acoust. Soc Am., POMA, https://doi.org/10.1121/2.0000627.

c. Gilbertson, L., and Lutfi, R.A. (2015). Estimates of decision weights and internal noise for the masked discrimination of vowels by young and elderly adults. J. Acoust. Soc. Am., 137:EL403-407. PMCID: PMC4441709.
d. Gilbertson, L. and Lutfi, R.A. (2014). Correlations of decision weights and cognitive function for the masked discrimination of vowels by young and old adults. Hear. Research, 317:9-14. PMCID: PMC4253306

2. Research on hearing has long been challenged with understanding our exceptional ability to 'hear out' individual sounds in a mixture. Two general approaches to the problem have been taken using sequences of tones as stimuli. The first has focused on our tendency to hear sequences, sufficiently separated in frequency, split into separate cohesive streams (auditory streaming). The second has focused on our ability to detect a change in one sequence, ignoring all others (auditory masking). The two phenomena are clearly related, but that relation has never been evaluated analytically. We have used detection theory to develop a theoretical analytic relation between multitone streaming and masking that underscores the expected similarities and differences between these phenomena and the predicted outcome of experiments in each case. The key to establishing this relation is the function linking performance to the information divergence of the tone sequences, *DKL* (a measure of the statistical separation of their parameters). A strong prediction is that streaming and masking of tones will be a common function of *DKL* provided that the statistical properties of sequences are symmetric. Results of our studies support this prediction.

a. Chang A.C., Lutfi, R., Lee J., and Heo, I. (2016). A detection-theoretic analysis of auditory streaming and its relation to auditory masking. *Trends Hear.*, 20:1-9. doi: 10.1177/2331216516664343. PMCID: PMC5029798.
b. Chang A.C., Lutfi, R.A., and Lee J. (2015). "Auditory streaming of tones of uncertain frequency, level and duration. J. Acoust. Soc. Am., 138(6):EL504-508. doi: 10.1121/1.4936981. PMCID: PMC4676779.
c. Lutfi, R.A., Gilbertson, L., Heo, I., Chang, A-C., and Stamas, J. (2013). The information-divergence hypothesis of informational masking. J. Acoust. Soc. Am., 134(3):2160-2170. doi: 10.1121/1.4817875. PMCID: PMC3765281.
d. Lutfi, R.A., and Liu, C.J. (2011). A method for evaluating the relation between sound source segregation and masking. J. Acoust. Soc. Am., 129(1):EL34-38. doi: 10.1121/1.3519871. PMCID: PMC3037974.

3. In recent years there has been growing interest in masking that cannot be attributed to interactions in the cochlea – so-called informational masking (IM). *Similarity* in the acoustic properties of target and masker and *uncertainty* regarding the masker are the two major factors identified with IM. These factors involve quite different manipulations of signals and are believed to entail fundamentally different processes resulting in IM. We have now accumulated evidence that these factors affect IM through their mutual influence on a single factor - the *information divergence* of target and masker given by Simpson-Fitter's *da* [Lutfi etal. (2012). J. Acoust. Soc. Am. 132, EL109-113]. We report studies of multitone pattern discrimination, multi-talker word recognition, sound-source identification and sound localization for which standard manipulations of masker uncertainty and target-masker similarity (including the covariation of target-masker frequencies) are found to have the same effect on performance provided they produce the same change in *da*. The function relating *d'* performance to *da*, moreover, appears to be linear with constant slope across listeners. The overriding dependence of IM on *da* is taken to reflect a general principle of perception that exploits differences in the statistical structure of signals to separate figure from ground.

a. Lutfi, R.A., Gilbertson, L., Heo, I., Chang, A-C., and Stamas, J. (2013). The information-divergence hypothesis of informational masking. J. Acoust. Soc. Am., 134(3):2160-2170. doi: 10.1121/1.4817875. PMCID: PMC3765281.
b. Lutfi, R.A., Chang, A-C., Stamas, J., and Gilbertson, L. (2012). A detection-theoretic framework for modeling informational masking. J. Acoust. Soc. Am., 132:EL109-13. doi: 10.1121/1.4734575. PMCID: PMC3407140
c. Oh. E., and Lutfi, R.A. (1998). Nonmonotonicity of informational masking. J. Acoust. Soc. Am., 104(6):3489-3499. PMID: 9857508.
d. Lutfi, R. A. (1993). A model of auditory pattern analysis based on component-relative-entropy. J. Acoust. Soc. Am., 94(2 Pt 1):748-758. PMID: 8370881.

4. We rely critically on our ability to identify simple objects and events from sound to function normally in the world. Yet, despite its importance, little is known regarding this ability. Perturbation analysis is a psychophysical method that has enjoyed success as a means of revealing decision processes underlying object identification in vision [Murray, R.F. 2011. J. of Vision 11**,** 1-25]. We have adapted this approach to the problem of sound source identification in audition. Three new findings have been made using this approach. They include (1) an unexpected constraint on identification imposed by limited auditory sensitivity, (2) an overriding influence of the highest level spectral prominences on identification, and (3) reliable individual differences in target enhancement and noise cancellation in the identification of targets in noise.

   a. Lutfi, R.A., Liu, C.J., and Stoelinga, C.N.J. (2013). A new approach to sound source identification. In *Basic Aspects of Hearing: Physiology and Perception*(vol. 787, pp. 203-213). Edited by B.C.J. Moore,, R.D. Patterson, I.M. Winter, R.P. Carlyon, and H.E. Gockel. (Springer: New York). ISBN: 978-1-4614-1589-3
   b. Lutfi, R.A., and Stoelinga, C.N. (2010). Sensory constraints on the auditory identification of the material and geometric properties of struck bars. J. Acoust. Soc. Am., 127(1):350-360. doi: 10.1121/1.3263606. PMCID: PMC2821150.
   c. Lutfi, R.A., Liu, C.J., and Stoelinga, C. (2008). Level dominance in sound source identification. J. Acoust. Soc. Am., 124(6):3784-3792. doi: 10.1121/1.2998767. PMCID: PMC2737249
   d. Lutfi, R.A. (2008). Human sound source identification. In *Springer Handbook of Auditory Research: Auditory Perception of Sound Sources* (pp. 13-42). Edited by W.A. Yost, A.N. Popper, and R.R. Fay (Springer-Verlag, New York). ISBN: 978-0-262-01341-3.

5. An unexpected finding of our previous work is that listeners show highly replicable, individualistic patterns of decision weights on frequencies in spectral discrimination tasks – what we refer to as *individual listening styles.* Importantly, these listening styles have been replicated over a period of months and are only manifest in the measurement of the decision weights as performance levels are found to be remarkably similar across listeners. We, like many researchers, have attributed these listening styles to peculiarities in how listeners attend to different frequencies, but our more recent work suggests they may also be influenced by how irregularities in cochlear micromechanics affect the relative level of frequencies transduced in individual cochleae (Lee et al., 2016).

   a. Lee, J., Heo, I., Chang, A-C., Bond, K., Stoelinga, C., Lutfi, R., and Long, G. (2016). Individual differences in behavioural decision weights related to irregularities in cochlear mechanics. Adv. Exp. Med. Biol., 894:457-65. doi: 10.1007/978-3-319-25474-6_48. PMCID: PMC5079619.
   b. Lutfi, R.A., and Liu, C.J. (2007). Individual differences in source identification from synthesized impact sounds. J. Acoust. Soc. Am., 122(2):1017-1028. doi: 10.1121/1.2751269. PMID: 17672650.
   c. Doherty, K.A., and Lutfi, R.A. (1999). Level discrimination of single tones in a multitone complex by normal-hearing and hearing-impaired listeners. J. Acoust. Soc. Am., 105(3):1831-1840. PMID: 10089606.

Complete List of Published Work:
https://www.ncbi.nlm.nih.gov/pubmed?term=Lutfi%20RA%5BAuthor%5D

D. Research Support

<u>Ongoing Research Support</u>

NIDCD R01 DC001262-26 Lutfi (PI) 02/15/2013 – 01/31/2019
Sound Source Segregation
The goal of this project is to advance our understanding of the normal processes underlying sound source segregation. The results may prove key in the development of technologies and rehabilitative strategies that deal more effectively with the impact of dysfunctional hearing on everyday listening.
Role: PI

<u>Completed Research Support</u>
None within the past 3 years