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1. REPORT DATE (DD-MM-YYYY) 17-01-2019		2. REPORT TYPE Final Report		3. DATES COVERED (From - To) 15-Aug-2014 - 14-Aug-2017	
4. TITLE AND SUBTITLE Final Report: Temporal Coherence Principle in Auditory Scene Analysis			5a. CONTRACT NUMBER W911NF-14-1-0519		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER 611102		
6. AUTHORS			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAMES AND ADDRESSES University of Maryland - College Park Office of Research Administration 3112 Lee Building 7809 Regents Drive College Park, MD 20742 -5141			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211			10. SPONSOR/MONITOR'S ACRONYM(S) ARO		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S) 63113-LS.2		
12. DISTRIBUTION AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT  UU	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Shihab Shamma
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU			19b. TELEPHONE NUMBER 301-405-6842

# RPPR Final Report

as of 24-Jan-2019

Agency Code:

Proposal Number: 63113LS

**Agreement Number: W911NF-14-1-0519**

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DUNS Number: 790934285

EIN: 526002033

**Report Date:** 14-Nov-2017

Date Received: 17-Jan-2019

**Final Report** for Period Beginning 15-Aug-2014 and Ending 14-Aug-2017

**Title:** Temporal Coherence Principle in Auditory Scene Analysis

**Begin Performance Period:** 15-Aug-2014

**End Performance Period:** 14-Aug-2017

**Report Term:** 0-Other

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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**STEM Degrees:** 2

**STEM Participants:**

**Major Goals:** The focus of the proposal was on the development of a computational realization of the idea of temporal coherence for the segregation of sounds and images, and an elaboration of the insights learned from simulations to disentangle complex sound sources such as speech and music. The temporal coherence model consists of a representational stage of early and cortical auditory processing that creates a multidimensional depiction of various sound attributes such as pitch, location, and spectral resolution. The following stage computes a coherence matrix that summarizes the pair-wise correlations between all channels making up the cortical representation. Finally, the perceived segregated streams are extracted by decomposing the coherence matrix into its uncorrelated components. Questions raised by the model are explored in depth, especially on the role of attention in streaming and the search for further neural correlates of streaming percepts.

**Accomplishments:** All major goals of the proposal listed in previous section were accomplished. These include the formulation of efficient versions of the model, reformulation of vision-based segmentation utilizing motion cues to the problem of sound. The algorithms have also been closely compared to new DNN-based versions and the similarities between the two have been identified. Finally, numerous recent tests of the temporal coherence ideas have also been tested using EEG experiments.

**Training Opportunities:** Many students were trained on the proposal, including 2 PhD and MS. Several PDOCs were also on the project. They are coauthors on the papers listed in next section.

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**Results Dissemination:** These papers were published and included much of the material discussed in the goals and the proposal accomplishments

Mehta, A. H., Jacoby, N., Yasin, I., Oxenham, A. J., & Shamma, S. A. (2017). An auditory illusion reveals the role of streaming in the temporal misallocation of perceptual objects. *Phil. Trans. R. Soc. B*, 372(1714), 20160114.

Lu, K, Y Xu, P Yin, A Oxenham, J B. Fritz, S. Shamma, (2017) Temporal Coherence Structure Rapidly Shapes Neuronal Interactions, *Nature Communications*, 8, 13900.

Mehta, A. H., Yasin, I., Oxenham, A. J., & Shamma, S. (2016). Neural correlates of attention and streaming in a perceptually multistable auditory illusion. *The Journal of the Acoustical Society of America*, 140(4), 2225-2233.

Wolf, G., Mallat, S., & Shamma, S. (2016). Rigid Motion Model for Audio Source Separation. *IEEE Transactions on Signal Processing*, 64(7), 1822-1831.

Akram, S., Presacco, A., Simon, J. Z., Shamma, S. A., & Babadi, B. (2016). Robust decoding of selective auditory attention from MEG in a competing-speaker environment via state-space modeling. *NeuroImage*, 124, 906-917.

Thakur, C. S., Wang, R. M., Afshar, S., Hamilton, T. J., Tapson, J., Shamma, S., & van Schaik, A. (2015). Sound stream segregation: a neuromorphic approach to solve the 'cocktail party problem' in real-time. *Frontiers in Neuroscience*, 9, 309.

O'Sullivan, James A., Shihab A. Shamma, and Edmund C. Lalor (2015) "Evidence for Neural Computations of Temporal Coherence in an Auditory Scene and Their Enhancement during Active Listening." *The Journal of Neuroscience* 35.18. 7256-7263.

Wolf G, S Mallat, S Shamma (2014) Audio source separation with time-frequency velocities, *Proceedings of the IEEE International Workshop on machine learning for signal processing*, Reims, France

Nelken, Israel, J Bizley, X Wang, S Shamma (2014) "Auditory Cortical Processing in Real-World Listening: The Auditory System Going Real." *The Journal of Neuroscience* 34.46 : 15135-15138.

Akram, S., Englitz, B., Elhilali, M., Simon, J. Z., & Shamma, S. A. (2014). Investigating the neural correlates of a streaming percept in an informational-masking paradigm. *PloS one*, 9(12), e114427.

Krishnan, L, M Elhilali, and S Shamma (2014) "Segregating Complex Sound Sources through Temporal Coherence." *PLoS computational biology* 10.12: e1003985.

**Honors and Awards:** Fellow of the Institute for Electrical and Electronic Engineers (IEEE)

William and Christine Hartmann Prize in Auditory Neuroscience,  
Acoustical Society of America

Chaires d'excellence, Paris Sciences & Letters University, 2016

K. Vaidyanathan Visiting Chair Professor, Indian Institute of Science, 2015

### Protocol Activity Status:

**Technology Transfer:** This algorithm was implemented in hardware with a view towards an eventual commercialization

Thakur, C. S., Wang, R. M., Afshar, S., Hamilton, T. J., Tapson, J., Shamma, S., & van Schaik, A. (2015). Sound stream segregation: a neuromorphic approach to solve the 'cocktail party problem' in real-time. *Frontiers in Neuroscience*, 9, 309.

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All information on the final progress of the grant are available in detail in the references given in the Dissemination SECTION