STSM Report

“Novel approaches for improving spatial sound discrimination in a multi-talker environment for tinnitus and hearing impaired sufferers”

COST ACTION: TINNET BM1306
Host TINNET member: Dr. Norbert Kopco
Host organization: Faculty of Science P.J. Safarik University, Slovakia
Visiting TINNET member: Dr. Carlos Trenado
Visitor’s affiliation: University Hospital Düsseldorf
Dates: May 28-June 4, 2017 (6 days)

Purpose of your mission

The main goals of the STSM were 1) development/tuning of an experimental paradigm to test the application of multisensory stochastic resonance for improving spatial sound discrimination in a multi-talker environment; 2) discussing the plausibility of novel approaches for tinnitus and hearing impairment rehabilitation with worldwide experts in audiology and auditory neuroscience as part of the grantee attendance to the meeting “3rd Workshop on cognitive neuroscience of auditory and cross-modal perception” that was organized by the host of the STSM.

Description of the work carried out during a mission

Goal 1:

- As a first step, we incorporated the capability of presenting one or two independent binaural noise sources into a behavioral and neurophysiological paradigm that has been utilized by the host for studying the effect of auditory and visual cuing on horizontal location discrimination (See Sebena et al. 2017, or Maddox et al., 2014 for a detailed description of the task). Accurate synchronization of trigger signals for auditory/visual stimuli generated by the psychotoolbox software was achieved by using Datapixx. We made use of a sound mixer to have simultaneous presentation of experimental stimuli and continuous noise from two independent sources.

- Since there are no previous studies reporting on noise properties to achieved stochastic resonance effects in an auditory location discrimination task, we decided to test the effect of two specific noises with broad spectrum, namely Gaussian white noise in the frequency ranges 0-100Hz and 0-300Hz at 5dB SL (above hearing threshold).

- Hearing threshold of noise stimuli was determined by means of a staircase procedure that was repeated three times. On the basis of the contrast between with vs. without noise, a broad-band Gaussian noise in the range 0-300 Hz was selected (Fig. (1)).

- The experimental session took place in a sound proof chamber, where subjects sat comfortably 50 cm apart from a computer monitor displaying a white circle, as a visual fixation point, that turned into gray by the time spatial sound stimuli was presented for each trial. During the experimental session, subjects were instructed to fixate their eyes on the circle located in the middle of the screen so that attentional resources were directed towards the auditory stimuli. Subjects were instructed not to blink during presentation of auditory stimuli.

- Electroencephalogram (32 channels: 10/20 system, sampling rate: 4096 Hz) was simultaneously recorded while subjects performed a sound discrimination task, which consisted of eight different stimuli categories (primer (center), probe (center): (A) shift left, (B) shift right; primer(right), probe(right): (C) shift left, (D) shift right; primer (right), probe(center): (E) shift left, (F) shift right; primer(center), probe(right): (G) shift left, (H) shift right) that were randomly presented in twenty blocks.

Goal 2:

- The guest presented a talk entitled "Sensorimotor improvement by stochastic resonance", which highlighted among auditory researchers the concept of stochastic resonance, while promoting fruitful discussions about the use of auditory noise in current sound discrimination approaches (https://pcl.upjs.sk/workshop2017/). The audience stressed the importance of characterizing the effect of different types of noises and thought of cross modal stochastic resonance as an innovative approach with the potential to speed up auditory training in tinnitus patients and people suffering from hearing impairment.

Description of the main results obtained

Our behavioral results favored the use of Gaussian white noise with broad-band frequency range (0-300Hz) as reflected by better performance in the discrimination of auditory stimuli (Fig. (1)).

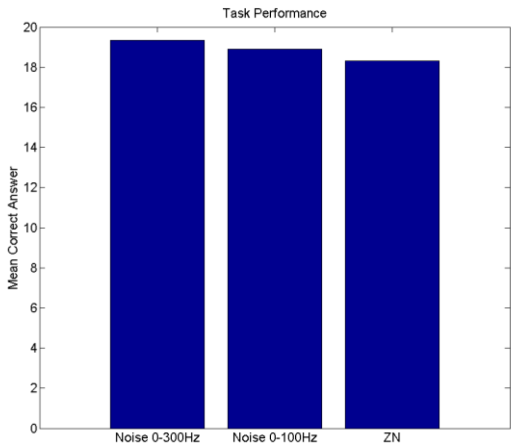

Fig. (1): Effect of Gaussian white noise (0-300Hz and 0-100Hz) and ZN (zero noise) on behavioral performance.

We found performance improvement for stimuli (A), (B), (C), (F) and (H) as depicted in Fig. (2).

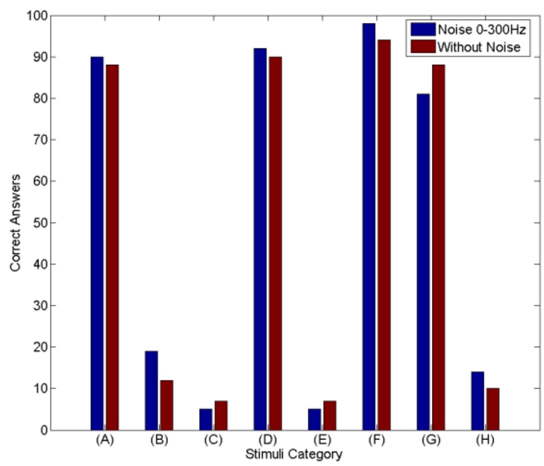

Fig. (2): Differential effect of 0-300Hz Gaussian noise on behavioral performance for each auditory condition (left).

Analysis of auditory evoked potentials (AEP) for the conditions Noise (Red) vs. ZN (Black) corresponding to the channel Cz exhibited differential effects across stimuli category: Fig. (3), Fig. (4), Fig. (5) and Fig. (6).

Fig. (3): AEPs corresponding to stimuli conditions (A) (left) and (B) (right). With respect to condition (A) a difference at 100 ms is noticeable.

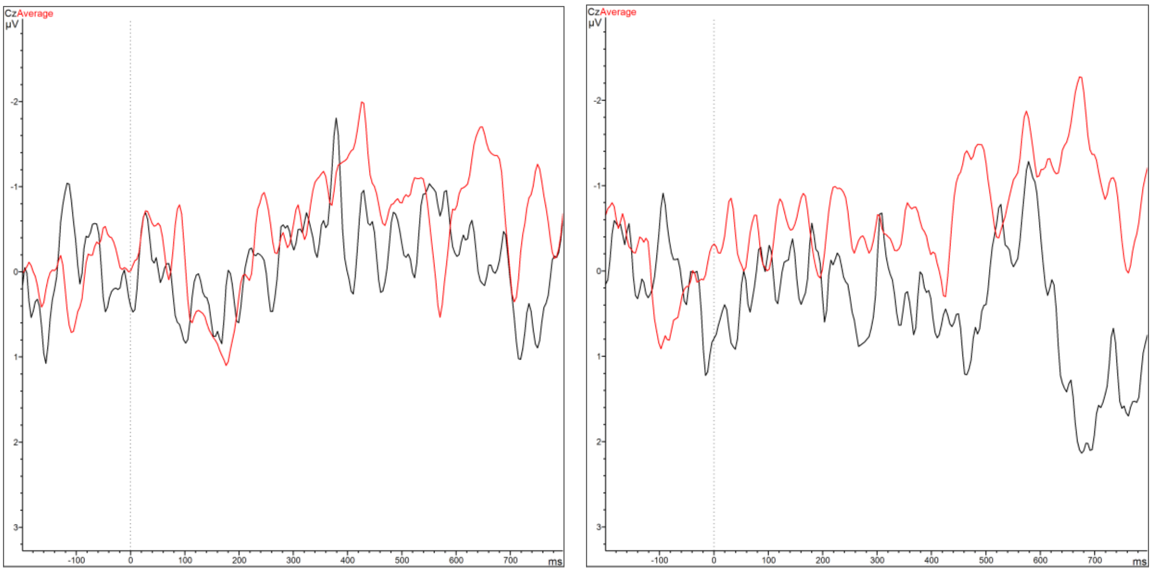

Fig. (4): AEPs corresponding to stimuli conditions (C) (left) and (D) (right). With respect to condition (D) a difference is noticeable around 300 ms.

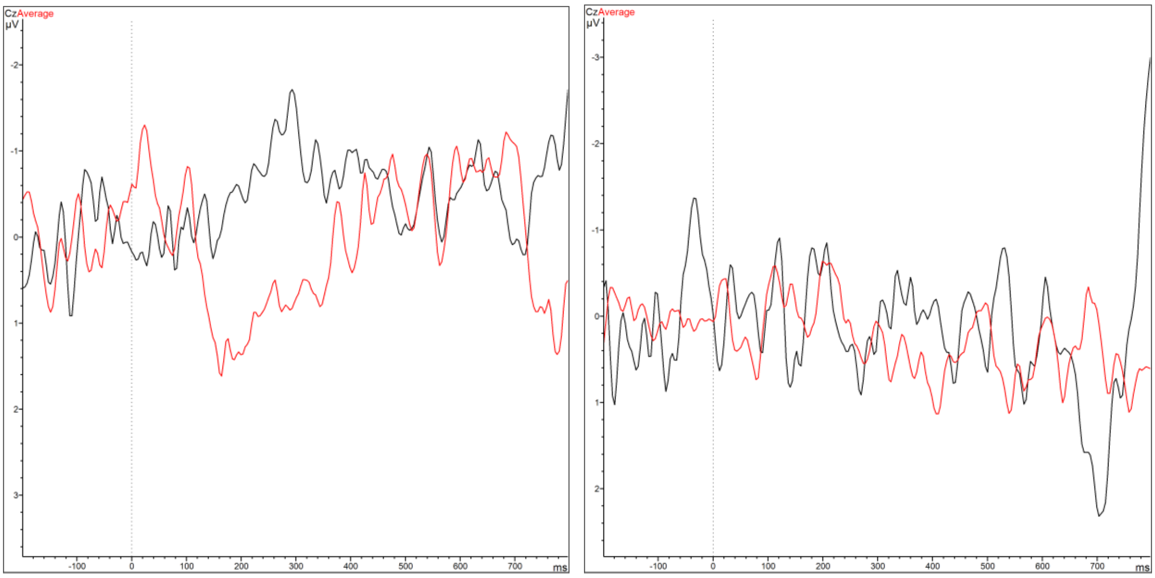

Fig. (5): AEPs corresponding to stimuli conditions (E) (left) and (F) (right). With respect to condition (E) a difference is noticeable at 100 ms and 300 ms.

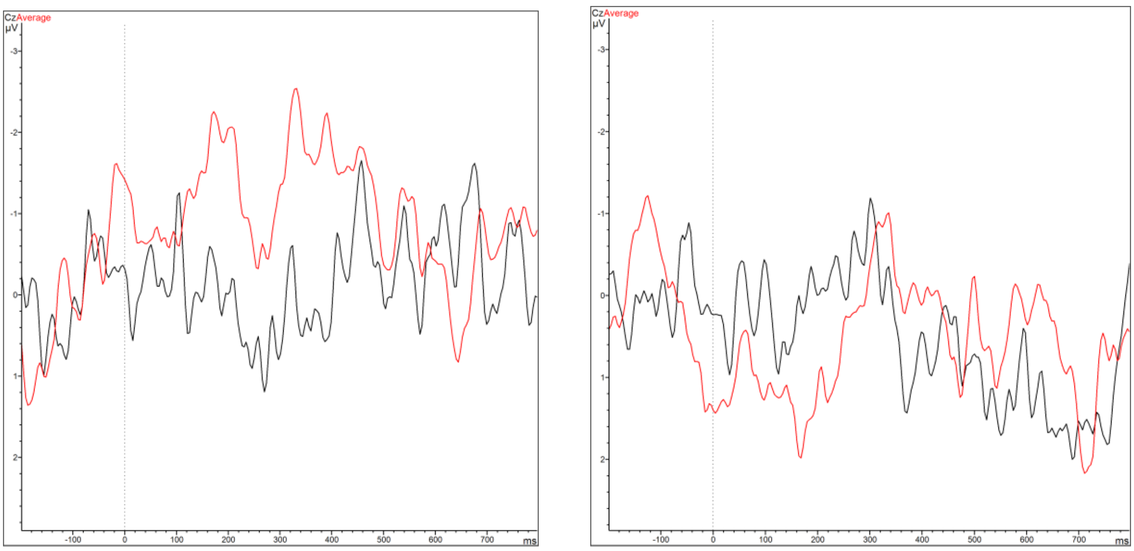

Fig. (6): AEPs corresponding to stimuli conditions (G) (left) and (H) (right). With respect to condition G) a difference is noticeable at 100 ms and 300 ms.

Future collaboration with the host institution (if applicable)

The present pilot study represents a proof of concept regarding improvement of spatial sound discrimination under effect of broad band Gaussian noise (0-300 Hz). A future collaboration with the host institution within the framework of cross modal stochastic resonance for auditory processing is expected.

Confirmation by the host institution of the successful execution of your mission

Hereby, I confirm that Dr. Carlos Trenado adhered to the planned activities during the scientific mission held at Safarik University and that his visit was beneficial for both parts. As a result of this STSM, we envision fruitful interactions and exchange of ideas into the field of auditory stochastic resonance for hearing impairment and tinnitus research.

Norbert Kopco

References

Šebeňa R, Hrebeňárová B, Kopčo N (2017) Auditory spatial discrimination with visual vs. auditory attentional cueing. Presented at Kognícia a umelý život (*Cognition and Artificial Life*), 31.5. – 2.6.2017, Trenčianske Teplice

Maddox RK, Pospisil DA, Stecker GC, Lee AK (2014) Directing eye gaze enhances auditory spatial cue discrimination. *Curr Biol.* 24(7):748-52. doi: 10.1016/j.cub.2014.02.021.