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Audiometric procedures in yearling southern elephant seals of Marion Island

Abstract

We used electro-encephalography (EEG) to measure auditory evoked potentials (AEP), especially the auditory brainstem responses (ABR) of immobilized southern elephant seal yearlings. The field study was conducted at the haulout sites of the seals close to the Marion Island Research Base (46°54'S, 37°45'E) between 12 and 24 April 2007. Two 1.5 years old seals were chosen for experiments focusing on a mapping procedure to identify areas on the seals' head most suitable for AEP recordings by seeking for optimal electrode placements, where signal to noise ratios are best. The poster shows the methodological approach, presents first results on audiometric procedures on southern elephant seals, and discusses the ecological relevance of audiometric investigations.

Fig. 1. Experimental set-up

Materials and methods

The portable experimental set-up was based on a four channel Tucker Davis RM2 mobile processor (Fig. 1). Major components include a 4-channel electrode pre-amplifier and digitizer in a low impedance head stage, a 24bit/96 kHz soundcard for stimulus generation and an Avisoft ultrasonic speaker for free field insonification. A calibrated Bruel&Kjaer 1/4" measurement microphone with a Bruel&Kjaer Nexus amplifier registered received sound pressure levels directly at the seal's ear. The system was powered by batteries. Programming of hardware was based on DSP software, and ActiveX programming interface software (all Tucker Davis), and MATLAB. Prior to the EEG recordings background sound levels were measured with a NTI AL1 acoustic analyzer. Disposable sterile monopolar 0.35 x 12 mm EEG needle electrodes were attached to the seals' scalp with the reference electrode being placed 4 cm rostral of a virtual line between the left and right acoustic meatus, and the ground electrode on the highest point of the seals' back.

Results

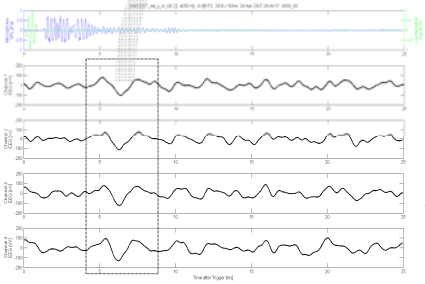
Mapping procedures were done in two animals with a total of 34 measurements. All measurements followed the same protocol with duration of 4 minutes for each sound display including data storage.

Basic audiometry

For each experiment 2000 tone pips of 4 kHz, a duration of 1 ms, and a ramped on- and offset were presented with a repetition interval of 50 ms. The received amplitude at the ear was around 90 dB re 20 µPa (Zero-Peak), as determined by a miniature microphone.

Four simultaneous EEG signals with an amplitude of ~100 µV were band pass filtered between 300-1500 Hz, and periods with high amplitude artefacts were removed. The result was averaged to obtain the ABR component (Fig. 2).

Fig. 2. Sample ABR display



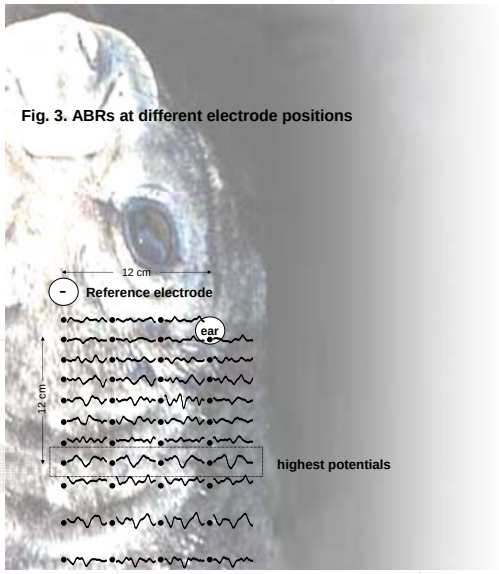
Electrode placement

Electrodes of the four channels were successively distributed over the course of the experiments as given in Fig. 3 (black dots), and yielded highest bio-potentials in an area 12 cm lateral of the median line and 12 cm behind the external meatus, where ABR amplitudes maximize up to 150 nV with latencies of 5 to 6 ms.

Constraints

Amplitudes of bioelectric signals in the EEG are extremely small, and can easily be masked by various factors. Swell and wind caused low frequency background sounds of between 20 and 250 Hz and 35-75 dB sound pressure level.

Fig. 3. ABRs at different electrode positions



Discussion

About 90% of marine mammal species including all Antarctic seals have not been audiometrically investigated as yet, and knowledge about their hearing is limited to assumptions based on measurements on similar species and frequency ranges of their own vocalizations. It is well known that hearing is possible in excess of up to several octaves beyond the vocalization frequencies since hearing has not only evolved as a function of communication; and marine mammals in particular have evolved to use sound and hearing as their primary means of perceiving their surroundings. Recordings of vocalizations related to reproductive or feeding behaviour as well as measurements of hearing abilities are therefore relevant to interpret population ecology as well as several other aspects of seal biology.

Summary

Maximum potentials were registered in an area 12 cm lateral of the median line and 12 cm behind the external acoustic meatus. This is the most suitable placement for electrodes to register acoustically evoked potentials (AEP) and especially auditory brainstem responses (ABR) in particular to investigate audible frequency ranges and corresponding hearing thresholds in yearling southern elephant seals.

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