15. Instrumentation in bioacoustical research: Neurophysiology

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Compared to other bioacoustical disciplines, auditory neurophysiology has three special requirements:
1) Precise stimulus and spike timing (down to microseconds)
2) Isolation of preparation from noise
3) To control the sound field in the presence of lots of equipment

1. Timing.

Stimulus timing.

Precise stimulus timing depend on careful calibration of the sound generation system with respect to both amplitude and phase. The system can be calibrated one frequency at a time, which is relatively time-consuming.

Alternatively, using digital signal processing the frequency response of the system can be 'flattened' both in amplitude and phase by calculating the transfer function between signal input and output and dividing the emitted signal by this transfer function (as in the microphone exercise). Note that it is necessary that the frequency response is not too peaky.

If hardware sound generators are used, they should be trigable, so the stimulus always start on an identical phase.

If computer sound cards are used, it is important that DA and AD converters are timed by the same clock.

Note that there is a conflict between making signals without onset and offset-clicks (i.e. with minimized frequency splatter) and making signals with a well-defined onset and offset.

Spike timing.

Spikes are usually recorded on

1. Paper
2. Tape recorder (also video tape)
3. Computer sound card (AD converter)
4. Computer controlled comparator and timer

For the analog devices (1 and 2) you need to check for jitter in the mechanism. For the digital devices 3 and 4, the accuracy is limited by the accuracy of the clock and response times of AD converter and comparator.

The simplest form of spike timing is to note when a spike crosses a detection threshold.

Note that this measure is dependent on

- the accuracy of the spike record (threshold set so no 'noise spikes' are recorded),
- the amplitude of the spike (if the amplitude decreases, for example, the spike will be detected later)
- noise (that will generate jitter in the spike timing, since the spike amplitude will fluctuate)

Therefore, for really precise timing, it probably would be safer to record the spikes with an AD-converter. Computer algorithms could then look for waveforms matching spikes and use the position of the peak as reference.

2. Isolation from Noise

Most equipment generates acoustical noise in the 50-1000 Hz range that can be reduced by placing the preparation in an isolated room or audiometric cabin, or by shielding the preparation. Note that part of the noise may be emitted as vibrations. Other sources of equipment noise can be crosstalk between electronic devices.

Preparations can fairly easily be isolated from ambient noise (in audiometric cabins), but low-frequency building vibrations (up to 10 Hz) can be difficult to shield from.

3. Control of the sound field.

Closed-field stimulation.

In closed-field stimulation the main requirement is that the sound presented in the coupler can be measured as close to the eardrum as possible in order to calibrate the device. Ideally, couplers should be pressure chambers with little internal reflection.

It is desirable to have a built-in microphone in the coupler. The coupler should ideally be as small as possible to avoid resonance or (worse) standing waves. The seal of the coupler to the ear is important especially for the low frequency response

Check for vibrations of the coupler housing (could stimulate ear by non-tympanic pathways)

Free-field stimulation.

A free field setup should be placed in an anechoic room. It is important that the setup itself is as small and compact as possible, including electrode holder and microdrive, animal support etc.

When stimulating with low frequency sound note that it is very difficult to avoid sound induced vibrations in the setup. Avoid placing the loudspeaker on the same table as the preparation to minimize vibration coupling.

The preparation should be minimally 1/6 wavelengths distance away from the loudspeaker to avoid local-flow stimulation.

In a free-field setup it is important to check for reflections. Anechoic rooms are usually only anechoic above a certain frequency, and the equipment may also generate reflections.