TRAINING SIGNAL DETECTION TASKS FOR DETERMINING SENSORY THRESHOLDS IN MARINE MAMMALS

Michelle Hanenburg*, Dr. Colleen Reichmuth
Long Marine Laboratory, University of California Santa Cruz, Santa Cruz, California

Research in the field of psychophysics often uses signal detection theory to measure an individual's sensitivity to a stimulus (Stebbins, 1970). While having an animal voluntarily participate in such research supports understanding of perceptual capabilities and sensory adaptations, the task of training an animal for signal detection presents several challenges. To explore the uniquely specialized sensory systems of amphibious marine mammals, our laboratory has trained basic signal detection tasks in a variety of species, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), northern elephant seals (*Mirounga angustirostris*), Steller sea lions (*Eumetopias jubatus*), ringed seals (*Pusa hispida*), spotted seals (*Phoca largha*), and Southern sea otters (*Enhydra lutris*).

Many behavioral signal detection tasks rely upon an animal's voluntary response to a sensory cue. Training for these tasks begins with the shaping of the desired response to a salient stimulus, one that the animal can readily perceive. The "Go/No-go" method of signal detection involves conditioning an animal to respond when it detects a signal, and to not respond in the absence of a signal (Schusterman, 1980). As training progresses and the animal's response to the initial stimulus undergoes stimulus control, the signal is gradually altered to promote generalization to similar stimuli, eventually allowing for testing to occur (Stebbins, 1970).

Trainers generally work to set their animals up for success, controlling the learning environment to minimize failure and frustration. In signal detection training, however, allowing animals to make errors is crucial. Errors serve to reveal the limits of performance that define sensory capabilities. Errors also allow the experimenter to gauge the reliability of the animal's response, and maintain consistency between sessions and with respect to other animals that may also be tested. Through the responses they give to signals near their sensory limits, animals can display response bias by tending towards positively responding to trials without stimuli, or failing to respond to signal trials. An individual's tendency towards a particular bias may be influenced not only by the individual, but also by species differences or experimental conditions. Through a variety of training examples, we found that creating a problem solving environment where the animal is given less active guidance and allowed to explore the consequences of its own behavior can facilitate a tolerance to errors that will aid the animal throughout the signal detection task (Schusterman, 1980).

While presenting many interesting challenges, the training of signal detection tasks utilizes the same principles of operant conditioning as other behavioral training (Stebbins, 1970). By incorporating the principles of signal detection theory we have been able to successfully train individuals of a variety of ages, species, and training backgrounds for signal detection tasks, as well as generalize the established behavior across modalities in order to explore a wide range of perceptual capabilities. Through the cultivation of enriching conditions that encourage active decision-making and exploration, we are also provided with insight as to how animals interact with their environment and can learn to modify and adapt their own behavior.

References

Schusterman, Ronald J. (1980). Behavioral Methodologies in Echolocation by Marine Mammals. In R. G. Busnel and J. Fish (Eds.), *Animal Sonar Systems* (pp. 11-41). New York: Plenum Press.

Stebbins, William C. (1970). Principles of Psychophysics. In W. C. Stebbins (Ed.), *Animal Psychophysics: the design and conduct of sensory experiments* (pp. 1-17). New York: Appleton- Century-Crofts

WEDNESDAY – 21 SEPTEMBER 2011

TRAINING A BOTTLENOSE DOLPHIN FOR DIRECT MEASUREMENTS OF SUBJECTIVE LOUDNESS

Linda Green[1]*, Erik Robinson[2], Carolyn E. Schlundt[3], James J. Finneran[4]
[1]SAIC, San Diego, California
[2]G2 Software Systems, Inc., San Diego, California
[3]ITT Corporation, San Diego, California
[4]US Navy Marine Mammal Program, Space and Naval Warfare Systems Center Pacific, San Diego, California

Over the last several decades there has been increasing concern over the potential adverse effects of underwater, human-generated noise on marine animals, primarily because of their sensitive, wideband hearing. However, present efforts to predict and mitigate the potential effects of noise on marine mammals are hampered by the limited amount of data that relate to the potential adverse effects (e.g., hearing loss) to the physical (measurable) parameters of noise (e.g., frequency, amplitude, duration). We conditioned a bottlenose dolphin (*Tursiops truncatus*) for a study designed to determine equal loudness levels. Equal-loudness contour is a measure of sound pressure (dB sound pressure level (SPL)), over the frequency spectrum, for which a listener perceives a constant loudness. Quantification of loudness in human listeners is straightforward; however, it is difficult to convey the concepts of loudness ranking or loudness matching to non-verbal animals, thus prior attempts to estimate equal loudness contours in animals have relied upon objective measurements. The present study demonstrates that a non-verbal animal can be conditioned for a subjective loudness-matching test and therefore it is possible to directly measure loudness levels in some animals. These data can then be used to derive equal loudness contours, which would allow for making predictions about the loudness of sounds with parameters for which data are lacking.

The total time for training the dolphin was approximately nine months. The loudness comparison test utilized a two-alternative, forced-choice paradigm. The subject was presented two sequential, 500-ms tones, separated by 500-ms of silence. The subject was trained to whistle if the first tone was louder than the second and to produce a burst pulse response (a rapid sequence of echolocation pulses) if the second tone was louder than the first. Training began by first conditioning the subject to produce each acoustic response when given a unique tactile cue. The tactile cues were then paired with sound stimuli consisting of tone pairs having a detectable frequency difference and a large SPL difference. The stimulus pairs therefore possessed an exaggerated transition effect of "loud to soft" or "soft to loud." Since the subject had previous experience whistling in response to hearing a single tone, focus was placed on training the burst pulse response to the "soft to loud" tone pairs first. The tactile cue for the burst pulse response was then faded out, and the subject conditioned to respond only to the sound stimuli. Once the subject's performance reached a criterion of >80% correct, training to elicit the whistle response to "loud to soft" tone pairs began in the same manner described above, and eventually the two tone-pair types were combined into a single session. Once the subject was able to demonstrate criterion performance to single trials of each type, the number of trials during a trial block increased. Finally, the frequencies and amplitudes of the stimuli were slowly changed, to condition the subject to generalize from the initial stimulus tone pairs to tone pairs of any frequency/amplitude combination, with the caveat that the SPL and frequency combination was such that the loudness relationship was known.

The data represent the first direct measurement of equal-loudness curves in any animal and show the relationship between the frequency and subjective loudness. Loudness contours may be more appropriate for assessing behavioral effects of sound, assuming behavioral reactions are more strongly related to *loudness* than *SPL*.