Frequency Characteristics in Animal Species Typically Used in Laryngeal Research: An Exploratory Investigation

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Summary: Objectives. Laryngeal research is typically conducted on animal species that have similar features to the human larynx, yet little is known of the frequency characteristics of those animals. This study examines frequency characteristics of dog, cat, pig, and sheep across emotional communication events.

Study Design. Prospective study.

Methods. Acoustic data were gathered in domestic environment, with fundamental frequency (f_o) computation of vocalization during happy, distress, and food request activities.

Results. Dogs demonstrated reduced f_o range and reduced vocalization as a factor of age (18 semitones for adult male dog, three semitones for aged male dog). When two barks were present, the second bark was typically shorter in length and had a higher f_o. Male cat was observed to be more talkative and exhibited a much higher purr f_o than his female housemate. Cat purr was varied by sex between the typical 25 Hz and a significantly higher f_o, consistent with literature on use of cry-purr by some cats. Lambs exhibited phonation breaks, and an overall frequency range of 28 semitones in lambs compared with 49 semitones for mature sheep. Piglets exhibited f_o range of 44 semitones with higher f_o with distress and lowest f_o for grunting.

Conclusions. Aged animals followed similar phonatory patterns of humans, with change of f_o for communication need. The male cat was found to purr differently from female cats. Pigs and cats may have nonlaryngeal source signal coupling. Animal phonation changes with emotion. Observed f_o patterns may improve interpretation of phonation among laboratory animals in laryngeal research.

Key Words: Phonation–Dog–Cat–Pig–Sheep–Lamb.

INTRODUCTION

New treatment options are routinely explored in the animal model before translation of techniques to humans. Despite the necessity of laryngeal research using animal specimens, little is known of the frequency characteristics of these animals commonly used in laryngeal research. Studies using animal models often describe the healing process post intervention, focusing on histology or laryngeal adduction behaviors,[1–5] and identification of cortical activity to trigger vocalization.[6,7] Most studies on animal vocalization have focused on characteristics from excised scarred vocal folds rather than *in vivo* frequency characteristics.[8,9] Tokuda et al[10] did study dog barks and piglet screams, finding nonlinear analysis useful. Yeon et al[11] observed higher fundamental frequency (f_o) and formants in feral cats compared with house cats. Kim et al[12] found lower f_o in young neutered dogs compared with intact young female dogs.

Studies on animal response to human vocalization have found that animals recognize emotions of humans.[13] Studies on emotion and human voice have found discernible phonatory differences for communication of joy, sadness, anger, tenderness, and neutral emotion.[14] Like humans, animals communicate with varied pitch patterns.

However, there remains a void in the literature on expected f_o characteristics during phonation among common animal models (dog, cat, pig, sheep), and few studies on the variability of f_o with change of communication demand (emotion).

Purpose of study

This *exploratory investigation* examines frequency characteristics of four domestic species of animals commonly used in laryngeal research (dog, cat, pig, sheep) across several vocalization events (greeting, distress, food request) to improve knowledge base for f_o capacity in those species. Use of domestic animals (home, farm) provides a more naturalistic environment for animal activities for daily living and common interactions. We also felt that animals in a domestic environment might be happier and more talkative than some laboratory animals.[15,16] Laboratory species do not typically have pretreatment recordings, and may not have the extent and comfort of f_o range because of environmental and behavioral limitations. Because new treatment options are explored in the animal model before use on humans, we felt that baseline description of f_o ranges in animals communicating across contrasting emotions should improve interpretation of posttreatment acoustic characteristics in the laboratory animal.

METHODS

Four animal species were volunteered and consented by their owners in this study to measure f_o across three different emotional states. When possible, species had additional variable for sex or age.

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Two neutered male dogs were used, one subject an adult Collie (age 5) and one subject an aged Labrador Retriever (age 14). Both dogs had similar weight and height, and are classified by the American Kennel Club as large breed dogs. Dogs were recorded indoors, in the home environment.

Two adult cats were used, one subject a 6-year-old male rescue cat (Orange Tabby) and one subject a 7-year-old female rescue cat (Tortoiseshell). Cats were of similar size (10–12 lbs), and both had been neutered. Cats were recorded indoors, in the home environment.

Eight lambs (aged 2–4 months, with some female and some male) and four mature male sheep (aged 3–4 years) were recorded outdoors in a family farm setting. Lambs and sheep had intact reproductive organs.

Eight piglets (aged 1–3 months, with some female and some male) with intact reproductive organs were recorded outdoors in a family farm setting.

Data were gathered in domestic (home, farm) environment with permission of owners and caregivers. The animal's typical caregiver engaged the animal to elicit the desired vocalization. Commentary was provided on the audio recording before the event task (approaching animal, feeding animal, etc) and/or following the event to identify specific animal vocalizing and intended message. Vocalizations were obtained during greeting (happy), distress (put me down, let me out), and food request activities.

Elicitation of "happy" vocalization was obtained through initial greeting or approach to the animal. Elicitation of "distress" was obtained through sudden exit of the caregiver or fearful (although previously experienced) physical posture. This included catching and picking up the pig or sudden abandonment of the dog by the caregiver shortly after greeting.

For the cats, distress phonation was achieved by placing the pet in a pet carrier bag (which was known to be a historically distressing experience for the cat). Elicitation of "food" vocalization was obtained through earlier than expected presentation of desired food (or treats). For the domestic cats, we achieved food request phonation by snapping the tab on the cat food can to indicate impending morning feeding time.

Acoustic signals were captured with Sony MZ-N707 Walkman Portable Minidisc Recorder (SONY, New York, New York), with a Sony ECM-MS908C Stereo Electret Condenser Microphone, at a distance of 6–12 inches from the animal's mouth. Signals were monitored with volume unit meter to ensure no clipping of signals, and were also monitored with Aiwa HP-X225 Stereo Dynamic Headset (SONY, New York, New York). Any clipped signals were eliminated from data analysis.

Data were transferred to an HP Pavilion dv2911us Entertainment Notebook PC (Hewlett-Packard, Palo Alto, California) and analyzed through the KayPentax MultiSpeech *Multi-Dimensional Voice Program* Model 5101 version 3.2 (PENTAX Medical, Montvale, New Jersey).

Vocal events were measured using peak-peak or zero-crossing hand calculation, depending on signal clarity, for a minimum of 20 consecutive cycles for each phonation (Figures 1–7). When phonations were shorter than 20 cycles, the maximum number of measurable cycles was computed. f_o was averaged for each communication event.

Semitone range for communication events was calculated with the standard formula (semitone difference = 39.86 × [log (f_o 1/f_o 2)]). Signals with episodes of clipping were discarded from analysis, and signals unrelated to animal vocalization were discarded.

RESULTS

Dogs

The aged dog (age 14 years) demonstrated reduced f_o range for communication events (Figure 8) when compared with the younger adult dog (age 5 years, Figure 9). Greatest f_o variability was during distress (whimpering). Lower f_o in the adult dog was observed when communicating to his master compared with when communicating to other members of the household. Overall range across all phonation events was also reduced for the aged dog compared with the younger dog (Table 1).

Cats

The cats were interesting. The male cat was very "talkative" (Figure 10) and exhibited a much higher purr f_o (264 Hz) than his female housemate (Table 2). The female cat liked to purr, but had a much lower f_o for purr (25 Hz) (Figure 11). The female cat limited her phonation events to purr. The male cat also loved to make smacking noises (2877 Hz) during eating, whereas the female cat ate quietly. For nonpurr and noneating sounds, the male cat f_o ranged 16 semitones. Other cat owners have reported that their male cats are much more "talkative" than female cats, which was consistent with our data.

Pigs

Piglets were found to have significant increase of f_o with fear and distress (capture), and a lowering of their distress f_o when they realized they were nearing the end of "danger" (lowering of captured pig to release into pig pen, Figure 12). Longer periods of holding the captured pig resulted in increased f_o. Only two piglets were captured and placed in a "distress situation" but their vocal behaviors were similar (Table 3).

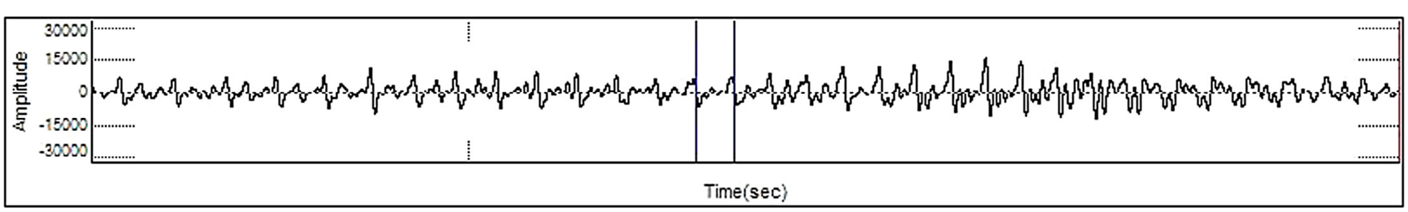

FIGURE 1. Sample adult dog bark signal.