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Phonetic Characteristics of Domestic Cat Vocalisations

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1. Introduction

The cat (*Felis catus*, Linnaeus 1758) has lived around or with humans for at least 10,000 years, and is now one of the most popular pets of the world with more than 600 million individuals [1], [2]. Domestic cats have developed a more extensive, variable and complex vocal repertoire than most other members of the Carnivora, which may be explained by their social organisation, their nocturnal activity and the long period of association between mother and young [3]. Still, we know surprisingly little about the phonetic characteristics of these sounds, and about the interaction between cats and humans.

Members of the research project Melody in human-cat communication (Meowsic) investigate the prosodic characteristics of cat vocalisations as well as the communication between human and cat. The first step includes a categorisation of cat vocalisations. In the next step it will be investigated how humans perceive the vocal signals of domestic cats. This paper presents an outline of the project which has only recently started.

1.1. Previous studies

The phonetic characteristics of domestic cat vocalisations were first described by Moelk [4], and since then a number of acoustic characteristics of cat vocalisations have been described [5]–[12]. Based on previous descriptions as well as analysis of new recordings, an attempt was made to develop a comprehensive phonetic typology of domestic cat vocalisations, with phonetic definitions. Table 1 shows the number of vocalisation types and subtypes identified so far.

Table 1: *The most common domestic cat vocalisation types and subtypes identified in this study.*

Vocalisation type	Subtypes
Meow	Mew, Squeak, Moan, Meow, Trill-meow
Purr	-
Trill	Chirrup, Grunt, Trill-meow
Howl	Howl, Howl-growl
Growl	Growl, Howl-growl
Hiss	Hiss, Spit
Snarl	-
Chirp	Chirp, Chatter

Auditory as well as acoustic analyses have been used to identify and describe the different types. The descriptions include phonetic transcriptions, segmental and prosodic features, as well as typical contexts in which the vocalisations are used. These types are now used in the project for

annotating and classifying cat vocalisations (see Figure 1 for an example waveform, spectrogram and fundamental frequency (F_0) contour of a vocalisation, and <http://meowsic.info> for additional video and audio examples.

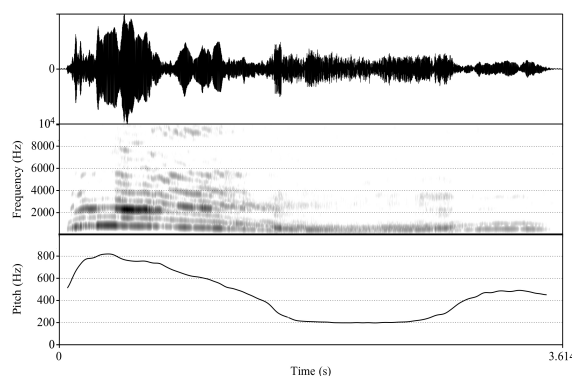


Figure 1: *Waveform (top), spectrogram (mid, bandwidth: 300 Hz) and F_0 contour (bottom) of an example howl-growl.*

2. Vocalisation types

The following list is an overview of the vocalisation types we have identified so far along with their subtypes. Example phonetic transcriptions and typical contexts in which the vocalisation types are used are provided for each type.

1. Sounds produced with the mouth closed
 - a. **Purr(ing)**: a low-pitched regular and probably nasalised sound produced during alternating (pulmonic) egressive and ingressive airstream: [↓h:ř-↑ř:h-↓h:ř-↑ř:h...] or ; used when the cat is content, hungry, stressed, in pain, gives birth or is dying; probably signals "I do not pose a threat" or "Keep on doing what you are doing".
 - b. **trill (chirr, chirrup, grunt, murmur)**: a short and often soft, sometimes a bit harsh nasalised sound rolled on the tongue, i.e. a voiced trill: [mhř:], [m:ř:ut], [bř:h]; used e.g. during friendly approach and greeting, and during play; grunts (murmurs) are usually more low-pitched, while trills or chirrup(s) are more high-pitched; sometimes cats combine a trill with a meow, producing the more complex vocalisation subtype trill-meow
2. Sounds produced with an opening-closing mouth
 - a. **meow (miaow) sounds**: Meows can be assertive, plaintive, friendly, bold, welcoming, attention soliciting, demanding, or complaining, sad or even silent. A meow can be varied almost endlessly, and there are several subtypes, including the following:

- i. **mew**: a high-pitched meow with [i], [ɪ] or [e] quality: [mi], [wɪ] or [mɪu]; kittens may use it to solicit attention from their mother, and adult cats may use it when they are sad or in distress or when they signal submissiveness
 - ii. **squeak**: raspy, nasal, high-pitched and often short mew-like call, sometimes with an [ɛ] vowel quality: [wæ], [mɛ] or [ɛʊ], sometimes not ending with a closing mouth; often used in friendly requests
 - iii. **moan**: with [o] or [u] vowels: [moau] or [mæu]; often used when sad or demanding
 - iv. **meow (miaow)**: a combination of vowels resulting in the characteristic [iau] sequence: [miau], [ɛau] or [wau]; often used in cat-human communication to solicit food or get past an obstacle (e.g. a closed door or window); adult cats mainly meow to humans, and seldom to other cats, so adult meow could be a post-domestication extension of mewling by kittens
- b. **trill-meow (murmur-meow)**: combination of a trill (murmur) and a meow: [mrhiau], [mhrɪj-au] or [whrrrau]; used in the same contexts as the meow
 - c. **howl (yowl, moan, anger wail)**: long and often repeated sequences of extended vocalic sounds – often with [ɪ], [i], [j], [ɣ], [aʊ], [ɛʊ], [aw], [ɔɪ], [aʊ] – usually produced by gradually opening the mouth wider and closing it again; used in threatening situations, and often merged or combined with growls in long sequences with slowly varying F₀ and intensity: [gr:awɪjaʊr:]
 - d. **mating cry (mating call)**: long sequences of meow-like sounds, sometimes similar to the cries of human infants; often used in spring during the mating season: [wɑ:u̇w], [ɪ:ɪ:au̇], [mhr:wɑ:ʊ:ɪ:ɪ:] or [R:w:u:a:u]
3. Sounds produced with an open tense mouth are often associated with either offensive or defensive aggression, but also with prey-directed vocalisations
 - a. **growl (snarl)**: long guttural, harsh, regularly and rapidly pulse-modulated, low-pitched sounds produced during a slow steady exhalation, often with the lip curled up and exposed teeth [gr:], with a vocalic [ɪ:] or rhotic [ʌ], occasionally beginning with an [m]; used to signal danger or to warn or scare off an opponent, and often intertwined or merged with howls and hisses
 - b. **hiss and spit** (the more intense variation): agonistic (aggressive and defensive) sounds produced with the mouth wide open and the teeth exposed, sounding a bit like long exhalations: [h:], [h:], [ç:], [ʃ:] or [ʒ:]; often an involuntary reaction to being surprised by an (apparent) enemy; the cat changes position with a startle and breath is being forced rapidly through the slightly open mouth before stopping suddenly; the spit sounds similar to a hiss, but may sometimes begin with a stop – often a t-like sound: [tʃ:], [ʃ:], [kʰ:]
 - c. **snarl (scream, cry, pain shriek)**: loud, harsh and high-pitched vocalic sounds, often with [a], [æ], [aʊ] or [ɛʊ] vowels: [æ:q]; often produced just before or during active fighting, or when in pain
 - d. **chirp and chatter (prey-directed sounds)**: a hunting instinct where cats copy the calls of their prey, e.g. when a bird or insect catches their attention (by making

a sound) and the cat becomes riveted to the prey, and starts to chirp, tweet and chatter:

- i. **chatter (teeth chattering)**: unvoiced very quick stuttering or clicking sequences of sounds with the jaws juddering, [k̄ k̄ k̄ k̄ k̄ k̄]
- ii. **chirp**: voiced short calls said to be mimicking a bird or rodent chirp, sound similar to a high-pitched phone ring, tone often rises near the end, [ʔə] or reiterated [ʔəʔəʔə...]
- iii. **tweet and tweedle**: tweets are soft weak chirps, often without any clear initial [ʔ] and with varying vowel qualities: [wi] or [hɛu]; tweedles are prolonged chirps or tweets with some voice modulation, like tremor or quaver: [ʔəɛəʔə]

Previous pilot studies have revealed that experienced human listeners are fairly good at recognizing the vocal signals of domestic cats [13], [14]. In future studies we intend to investigate this further.

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