# A phonetic pilot study of vocalisations in three cats

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## Abstract

*538 vocalisations from three domestic cats were collected and used in a phonetic pilot study in order to test some recording and analysis methods normally used with human speech. Based on auditive analysis, the vocalisations were categorised into five types and analysed for duration and $F_0$. The most common type was a combined murmur and miaow. Similar mean type durations were found in all three cats. Mean, minimum and maximum $F_0$ showed an overall high variability, due to the large number of intonation patterns used in each type. One might speculate that cats signal paralinguistic – perhaps even linguistic – information by varying their $F_0$. Neither the recording techniques nor the analysis tools used here were judged to be optimal for cat vocalisations. Future work includes a larger study of cat vocalisations, including intonation and formants, with adapted recording and analysis methods.*

## Introduction

The cat (Felis *catus,* Linneaus 1758) was domesticated 10,000 years ago, and has become one of the most popular pets of the world with more than 600 million individuals (Turner & Bateson, 2000; Driscoll et al., 2009). Its vocalisation repertoire is characterised by ”an indefinitely wide variation of sound and of patterning” (Moelk, 1944). Still, the few existing phonetic studies of cat vocalisations report findings from only a small number of cats, vocalisation types, or methods (e.g. Moelk, 1944; Brown et al., 1978; McKinley, 1982; Shipley et al., 1988, 1991; Farley et al., 1992, Nicastro & Owren 2003, Yeon et al. 2011).

### Cat vocalisations

Vocal cat sounds are generally divided into three major categories (Moelk 1944, Crowell-Davis et al. 2004): (1) sounds produced with the mouth closed (murmurs), including the purr, the trill and the chirrup, (2) sounds produced with the mouth open and gradually closing, comprising a large variety of miaows with similar vowel-patterns [ɑːou], and (3) sounds produced with the mouth held tensely open in the same position, often uttered in aggressive situations (growls, yowls, snarls, hisses, spits, and shrieks). Moelk (1944) further divided the these categories into four murmur patterns, six vowel patterns, and six strained intensity patterns, and identified 16 different phonetic patterns, including acknowledgement, bewilderment, refusal, demand, and complaint. McKinley (1982) identified nine pure and six complex (composed of two or more) vocalisation types.

The purpose of this study was to prepare for a larger study by testing some recording and analysis techniques normally used for human speech on cat vocalisations. The aim was to learn more about the phonetic characteristics of the most common types of cat vocalisation.

## Material and method

A total of 538 vocalisations were collected opportunistically over a period of one month from three domestic shorthaired cats: Donna, Rocky and Turbo (*D*, *R* and *T*; 1 female, 2 males, all 18 months old siblings from the same litter).

### Recording procedure

The cats were recorded in their home with two different set-ups. One consisted of two Stage Line ECM-302 B boundary microphones connected to a Marantz PMD660 digital recorder. The microphones were placed either in the kitchen or a room used for playing, while the recorder was kept in an adjacent room so that recordings could be made without disturbing the cats. The other set-up was an Apple iPhone 3G, occasionally together with a Blue Mikey USB microphone. This setup allowed “on the fly” recordings whenever and in whatever room the vocalisations occurred. All recordings were transferred to a computer (Wave, 44,1 kHz/16 bit) for further analysis. Care was taken to record as spontaneous vocalisations as possible. As purring had already been investigated in an earlier study (Schötz & Eklund, 2011), very few instances of purring were recorded. Also, no aggressive vocalisations were uttered during the recording sessions.

### Categorisation and analysis procedure

The vocalisations were categorised into five rather crude vocalisation types based on auditive analysis and the categories used by Moelk

(1944) and McKinley (1982). *Chatter (C)* was uttered by the cats of this study when unable to reach a bird outside the window. It can be described phonetically as a glottal stop [ʔ] followed by a short vowel, e.g. [ə] or [ɛ], produced with an open mouth, often in sequences [ʔɛʔɛʔɛ...]. *Miaow (M)* was used for a group of sounds produced with an opening-closing mouth, often uttered during play and in anticipation of feeding. McKinley (1982) subdivided this type into four patterns based on the pitch and the vowels following: *the mew*, a high-pitched call with [i], [ɪ] or [e] quality; *the squeak*, a raspy nasal high-pitched mew-like call; *the moan*, an [o] or [u] like opening-closing sound; and *the meow*, a combination of vowels resulting in a characteristic [iau] sequence. *Murmur (R)* was used for the short soft voiced trill or purr, sounding like [mhrn] or a creaky [m̰]. It was uttered with the mouth closed during friendly approach and play. *Murmur-miaow (RM)* was used for a combination of a murmur and one of the miaow patterns, uttered in similar situations as the individual (pure) sounds. Less frequent vocalisation types, including purring and longer phrases, were categorised as *other (OTH)*, and excluded from further analysis. The vocalisation types are listed in Table 1. Figure 1 and Table 2 display the number and proportion of vocalisations of each pattern by the three cats.

*Table 1. Vocalisations types used in the study.*

| *Type* | *Descriptive terms* |
|---|---|
| C | *Chatter*, teeth chattering |
| M | *Miaow*, mew, squeak, moan, meow |
| R | *Murmur*, trill |
| RM | *Murmur-miaow*, combination of R and M |
| OTH | *Other* sounds (e.g. purring, longer phrases) |

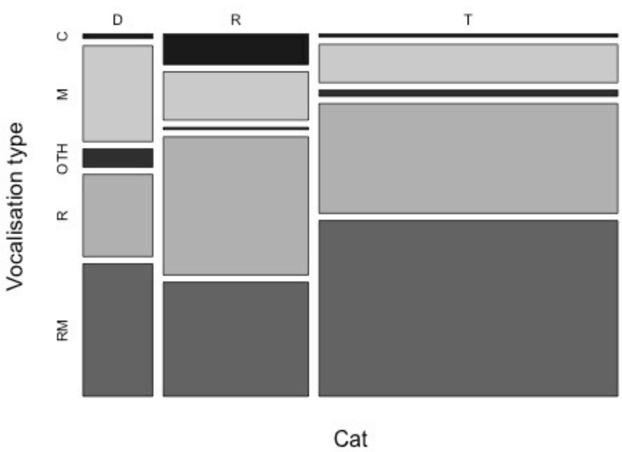


Figure 1. Mosaic plot of the proportions of the five vocalisation types: *chatter* (C), *miaow* (M), *other* (OTH), *murmur* (R), and *murmur-miaow* (RM) for the three cats (D, R, T).

*Table 2. Number of vocalisations of the three cats in the pilot study divided by type (C = chatter, M = miaow, R = murmur, RM = trill-miaow, OTH = other).*

| *Cat* | *C* | *M* | *R* | *RM* | *OTH* | *Total* |
|---|---|---|---|---|---|---|
| D | 1 | 21 | 18 | 29 | 4 | *73* |
| R | 14 | 22 | 63 | 52 | 1 | *152* |
| T | 3 | 36 | 103 | 165 | 6 | *313* |
| *Total* | *18* | *79* | *183* | *246* | *11* | *538* |

Measures of duration and $F_0$ were obtained with a Praat (Boersma and Weenink, 2012) script and manually checked. As the signal-to-noise ratio was judged to be too low in many of the recordings, no formant analysis was done.

## Results

The most frequent vocalisation type found was the murmur-miaow (RM) with 246 tokens, followed by the murmur (183 tokens), the miaow (79 tokens) and the chatter (17 tokens). T was the most vocal cat with a total of 313 recorded vocalisations, followed by R (152 vocalisations) and D (73 vocalisations). The results of the four most frequent vocalisations patterns are described below. Median values were very close to mean values, and therefore only mean values are presented here.

### Chatter (C)

Chatter was the least frequent vocalisation type of this study with only 18 tokens. The mean duration of all tokens for this type was 0.74 seconds. The $F_0$ contour was often level around 400-600 Hz. Minimum $F_0$ was 130 Hz, maximum $F_0$ 903 Hz, and mean $F_0$ 580 Hz. These values, as well as individual values for each cat, are shown in Table 3. Figure 2 shows the waveform, broadband spectrogram and $F_0$ contour of an example of a single chatter. This vocalisation type also appeared in phrases of up to ten repetitions. The mean duration for T is longer than for the other two cats because he produced such sequences.

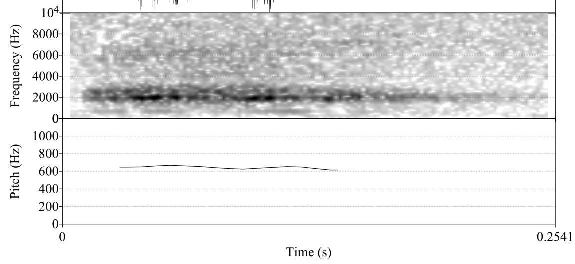


Figure 2. Example waveform, broadband (300 Hz) spectrogram and $F_0$ contour of chatter (C).

*Table 3. Mean durations, as well as minimum, maximum and mean $F_0$ of chatter (C).*

| *Cat* | *meanDur* | *min$F_0$* | *max$F_0$* | *mean$F_0$* |
|---|---|---|---|---|
| D | 0.61 s | 373 Hz | 444 Hz | 402 Hz |
| R | 0.46 s | 130 Hz | 903 Hz | 618 Hz |
| T | 2.12 s | 337 Hz | 609 Hz | 472 Hz |
| *All* | *0.74 s* | *130 Hz* | *903 Hz* | *580 Hz* |

### Miaow: mew, squeak, moan, meow (M)

Miaows had a mean duration of 0.42 sec., and a mean $F_0$ of 698 Hz, with a rather large $F_0$ range from 221 to 1185 Hz. A level $F_0$ was the most common, but rising and falling $F_0$ contours were also observed. Numeric values for this type are shown in Table 4, and Figure 3 displays a miaow (in this case a meow) example.

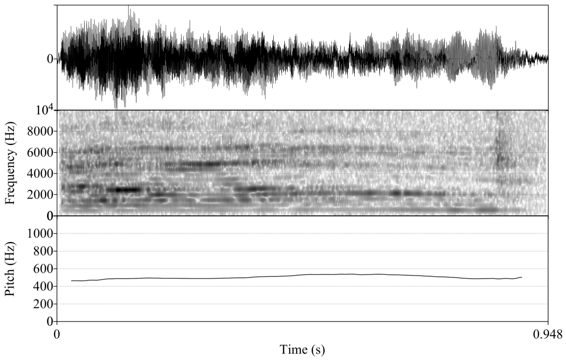


Figure 3. Example waveform, broadband (300 Hz) spectrogram and $F_0$ contour of miaow (M).

*Table 4. Mean durations, as well as minimum, maximum and mean $F_0$ of miaow (M).*

| *Cat* | *meanDur* | *min$F_0$* | *max$F_0$* | *mean$F_0$* |
|---|---|---|---|---|
| D | 0.42 s | 527 Hz | 1099 Hz | 879 Hz |
| R | 0.52 s | 303 Hz | 1000 Hz | 747 Hz |
| T | 0.62 s | 221 Hz | 1185 Hz | 892 Hz |
| *All* | *0.54 s* | *221 Hz* | *1185 Hz* | *698 Hz* |

### Murmur (R)

Murmur was the second most common vocalisation type, with a mean duration of 0.51 sec. $F_0$ contours (97–1164 Hz) were level, rising or falling, with a mean $F_0$ of 533 Hz, as shown in Table 5. Figure 4 shows an example of a murmur.

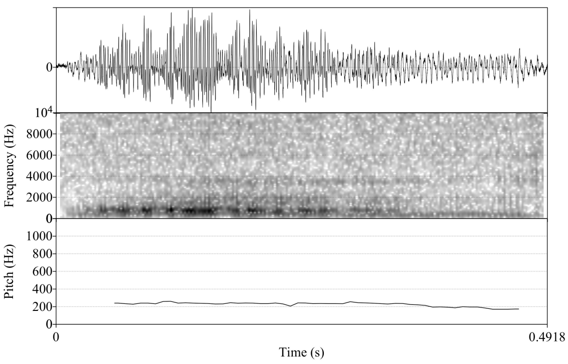


Figure 4. Example waveform, broadband (300 Hz) spectrogram and $F_0$ contour of murmur (R).

*Table 5. Mean durations, as well as minimum, maximum and mean $F_0$ of murmur (R).*

| *Cat* | *meanDur* | *min$F_0$* | *max$F_0$* | *mean$F_0$* |
|---|---|---|---|---|
| D | 0.40 s | 371 Hz | 1164 Hz | 740 Hz |
| R | 0.48 s | 97 Hz | 501 Hz | 253 Hz |
| T | 0.54 s | 135 Hz | 670 Hz | 342 Hz |
| *All* | *0.51 s* | *97 Hz* | *1164 Hz* | *358 Hz* |

### Murmur-Miaow (RM)

With a mean duration of 0.80 seconds, the murmur-miaow was the longest as well as the most common vocalisation type. The frequently rising $F_0$ contour ranged from 111 to 1082 Hz, with a mean value of 533 Hz. Figure 5 shows a typical murmur-miaow example, and Table 6 display the values for this type.

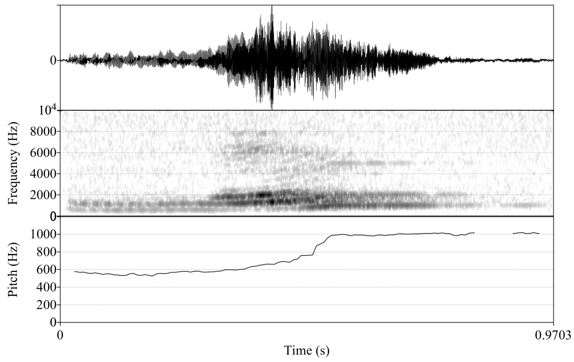


Figure 5. Example waveform, broadband (300 Hz) spectrogram and $F_0$ contour of murmur-miaow (RM).

*Table 6. Mean durations, as well as minimum, maximum and mean $F_0$ of murmur-miaow (RM).*

| *Cat* | *meanDur* | *min$F_0$* | *max$F_0$* | *mean$F_0$* |
|---|---|---|---|---|
| D | 0.74 s | 254 Hz | 1082 Hz | 752 Hz |
| R | 0.80 s | 162 Hz | 1043 Hz | 591Hz |
| T | 0.81 s | 111 Hz | 930 Hz | 475 Hz |
| *All* | *0.80 s* | *111 Hz* | *1082 Hz* | *533 Hz* |

## Discussion

The recording techniques used in this study, though relatively easy to use, had several drawbacks. Cat vocalisations are often low in sound pressure level, and the long distance to the microphone often led to a rather noisy sound quality. Therefore, the results of the acoustic analysis should only be regarded as preliminary.

Acoustic analysis of cat $F_0$ using the speech analysis software Praat was problematic. Several parameters for $F_0$, including the floor and maximum pitch, needed adjusting. Manual correction of pitch contours was also often necessary. When conducting more extensive acoustic-phonetic studies of cat vocalisations, better adapted tools are needed, especially for $F_0$ and formant analysis.

The murmur-miaow (RM) was the most frequent vocalisation type in this study. McKinley (1982) and Moelk (1944) also identified complex vocalisation types, and these findings support the large vocal repertoire of the cat.

A large inter- and intra-cat variation in mean, maximum and minimum $F_0$ was found in all of the four vocalisation types. The rather small sample size may have contributed to this. Some of the variation may also be explained by sex and individual voice differences of the cats. Intra-cat variation is more likely to be caused by the large number of different intonation patterns within each type. One might speculate that cats are able to signal paralinguistic – perhaps even linguistic – information by combining vocalisation types and varying their $F_0$.

Future work includes a larger study of cat vocalisations, including intonation and an initial formant analysis of the different vocalisation types, especially the vowels. In addition, a comparison of cat-directed and human-directed vocalisations will be made.

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Figure 6. The three cats Donna, Rocky and Turbo, who participated in this pilot study.

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