Paralinguistic Information and Biological Codes in Intra- and Interspecific Vocal Communication: A pilot study of Humans and Domestic Cats

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Abstract

This pilot study is an attempt to explore how fundamental frequency (f0) as an acoustic correlate to paralinguistic information and biological codes are employed in interspecific vocal communication. Measures of f0 in human *(Homo sapiens)* and domestic cat *(Felis catus)* intra- and interspecific communication were compared. Results showed higher mean f0 in interspecific than intraspecific utterances for both species, while all cat-directed utterances had higher f0 range and standard deviation (sd).

Introduction

In human–cat and other interspecific vocal communication the message is usually not mainly linguistic. Although research has shown that some species seem to understand simple words and utterances, most of the communication between humans and other animals still relies on other information in the vocal signal, usually combined also with visual, tactile and olfactory cues. The relative importance of vocal features in human–cat communication is still unclear. It is also still unknown to what extent cats and humans employ the more universal features present in both human and animal voices; paralinguistic information and biological codes, in their interspecific communication.

Paralinguistic information in speech

Paralinguistic information, sometimes also referred to as extralinguistic or nonlinguistic information, concerns those aspects of speech that do not belong to the arbitrary conventional language code, but which nevertheless are meaningful, important and always present in speech communication (see e.g. Gussenhoven, 2016; Ní Chasaide & Gobl, 1997, pp. 456–8; Schötz, 2002, 2003). Humans speech varies articulatory and acoustically as a function of the speaker (e.g. age, sex, anatomy, personal voice quality, dialect or accent, physical and mental state, emotion and attitude), the audience (e.g. age, sex, social relation to speaker) and the physical environment (e.g. distance between speaker and listener). These factors can be further categorised into four different quality types that listeners usually are able to perceptually separate. *Linguistic quality* is the conventional and social information including the message, dialect and speech style. *Expressive quality* depends on the psychological state (e.g. emotion and attitude) of the speaker. *Organic quality* varies with speaker anatomy, age and health. *Perspectival quality* varies with place (or channel), distance and orientation to the speaker (Traunmüller, 2000).

Biological codes in speech

Expressive and organic information in speech are sometimes classified as 'biological codes', usually realised as variation in f0 and voice quality. Biological codes tend to be universal, and some are even used by animals. The *frequency code* associates high f0 with "small" meanings, like submission, vulnerability, uncertainty, and friendliness, while low f0 is associated with "big" meanings like dominance, aggressiveness, certainty, and protectiveness (Ohala, 1984, 1994; Gussenhoven, 2016). According to the *effort code,* a wider pitch range and more precisely produced f0 patterns signal prominence (focus), and cooperativeness, e.g. in child-directed speech (Gussenhoven, 2016). The *respiratory (or production) code* associates the declining f0 of a breath group with beginnings and ends of phonological units. High f0 in the beginning of a phrase indicates a new topic, while low f0 signals the continuation of a topic. At the end of a phrase, high f0 indicates maintenance, and low f0 a turn shift (Gussenhoven, 2002). The *sirenic code* relates a breathy or husky voice quality with intimacy, friendliness, timidity and feminine sexiness (Gussenhoven, 2016).

Interspecies vocal communication

Human speakers are generally sensitive to the acoustic preferences, emotional needs and potential linguistic ability of their audience. For instance, infant-directed speech (IDS) and pet-directed speech (PDS) has been shown to differ from adult-directed speech (ADS) in some shared acoustic features (shorter utterance duration, elevated f0 and exaggerated f0 contours), and also in repetitiveness and rated affect in low-pass filtered stimuli. However, hyperarticulated vowels and imperatives were mainly observed in IDS, while PDS was characterised by shorter sentences and more exact repetitions, suggesting that humans usually do not expect other species to understand the linguistic message (Burnham et al., 2002; Mitchell, 2001).

Although still controversial, it has become increasingly acceptable to talk about animal emotions since the nineteenth century (Darwin, 1927; de Waal, 2016, p. 41). The ability of non-human animals to utilize vocal signals to express emotion has evolved over a long period of time and serves several biological functions; locating and identifying individuals, mobilizing the recipient to action or activating their attention, calming or alarming, and also has agonistic (promoting escape or dispersion), affiliative (signalling approach and promoting conspecific contact), phatic (maintaining connections among individuals and enhance group cohesiveness) and hedonic (informing of joyful states and situations) functions (Brudzynski, 2017).

Animal species in previous studies of interspecies vocal communication between humans and other animals include grey parrots (Pepperberg, 2014), primates (Hostetter, Cantero, & Hopkins, 2001; Leinonen, Linnankoski, Laakso, & Aulanko, 1991), dogs (Yeon, 2007), and pigs (Tallet, Špinka, Maruščáková, & Šimeček, 2010). Many of these studies suggest that humans and other animals share a number of vocal patterns for signalling physical and mental state, including mood, attitude and affect (emotion). Acoustic correlates to such paralinguistic information can be found in f0, intensity, duration and voice quality (see e.g. Gangamohan, Kadiri, & Yegnanarayana, 2016).

Human-cat vocal communication

Humans usually talk frequently to their cats, and cats often vocalise when they communicate with humans. In cat–cat communication, vocalisations are mainly used in sexual, mother–offspring and territorial or agonistic situations. Cats have developed a large and highly varied vocal repertoire which should allow them to express their mental state and their desires, needs and intentions. Moreover, they have learned to vary their voices to get the attention of their human caretakers when they want or need something (e.g. receive food, open a door). (Bradshaw, Casey, & Brown, 2012; Turner & Bateson, 2000). Cats seem to be able to identify their owners' voices and also their own names (Saito & Shinozuka, 2013; Saito, Shinozuka, Ito, & Hasegawa, 2019). However, despite several recent studies on how cats and humans perceive emotional and contextual cues in each other's voices, it remains unclear to what extent cats and humans can identify biological codes and paralinguistic information (e.g. emotions) in interspecific vocal communication (Schötz & van de Weijer, 2014; Schötz, 2014; Merola, Lazzaroni, Marshall-Pescini, & Prato-Previde, 2015; Ellis, Swindell, & Burman, 2015; Galvan & Vonk, 2016).

Purpose and aim

The purpose of this pilot study is to explore measures of f0 in human–cat vocal communication with the aim to learn more about to what extent f0 is used to signal paralinguistic information and biological codes. The main research question is how f0 mean, range and sd varies in intra- and interspecific communication for both species. This is still work in progress with only a small set of data.

Material and method

The material consisted of recordings taken either from the project Melody in Human–Cat Communication (Meowsic) (Schötz, Eklund, & van de Weijer, 2016) or from previous studies of human- and cat-directed cat vocalisations (Schötz, 2012, 2015). Samples of human- and cat directed speech (HDS and CDS) by four female and four male speakers were analysed for f0 mean, range and sd. The duration of the speech samples varied between 1.7 and 22 seconds, with an average of 6.85 sec. Additionally, cat vocalisations of two types with typically wide f0 ranges (howl-growls and trill-meows) from three cats (one female, two males) were analysed in the same way for comparison. The mean duration of the cat vocalisation samples was 105 (11–417) seconds. Howl-growls were selected to represent cat-directed vocalisations (CDV) as they are generally used in agonistic contexts to warn and scare off conspecific intruders. Trill-meows are frequently used when soliciting the attention of humans and were selected to represent human-directed vocalisations (HDV). All analyses were done in Praat (Boersma & Weenink, 2019).

Results

Human- vs. cat-directed speech

Both female and male human speakers generally had higher f0 values in CDS compared to HDS (see Table 1 and Figure 1). The average f0 mean, range and sd values respectively for female HDS were 185, 142, and 27, and for CDS 301, 358, and 84. For male speakers the same values were 104, 50, and 12 for HDS and 164, 189, and 47 for CDS.

Cat- vs. human-directed vocalisations

As seen in Table 2 and Figure 1, all three cats had higher f0 mean in HDV (615) compared to CDV (447), but higher f0 range and sd in CDV (454, 120) than in HDV (213, 72).

Discussion

Human- vs. cat-directed speech

Despite the small data set, the results of higher f0 mean and range in CDS compared to HDS are in line with previous studies comparing adult- and pet-directed speech (Burnham et al., 2002; Mitchell, 2001). It also indicates that human cat owners signal tenderness, happiness, affiliation and cooperativeness using paralinguistic information and the frequency and effort codes when addressing their cats. However, it is still unclear whether cats perceive these cues as meaningful information. It is reasonable to assume that cats can perceive expressions of emotion and possibly even other paralinguistic information in other cats' voices, for instance when kittens cry for their mothers' help, so it is likely that they are able to perceive at least some of this information in human speech as well.

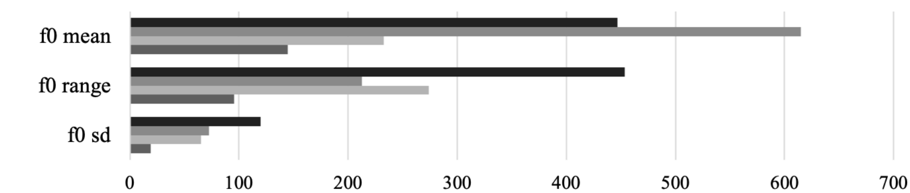
One additional difference between HDS and CDS was that CDS was often produced with more breathy voice quality. A possible explanation for this may be that humans use the sirenic code with their cats to signal friendliness and intimacy.

Table 1. Measures of duration (dur) and f0 (mean, range, standard deviation (sd)) (Hz) in human-and cat-directed speech by four female and four male speakers.

Speaker ID	*Human-directed speech*				*Cat-directed speech*			
Female	*dur*	*f0 mean*	*f0 range*	*f0 sd*	*dur*	*f0 mean*	*f0 range*	*f0 sd*
h02a	3.94	198	89	19	22.03	341	553	127
h03a	2.94	200	111	23	10.23	337	311	83
h08a	11.96	149	218	33	12.84	277	357	73
h09a	4.75	193	149	33	3.42	247	211	52
Male								
h02b	5.34	98	47	10	3.38	152	149	36
h03b	4.24	95	56	13	11.15	126	125	35
h08b	2.08	95	37	11	6.53	191	273	54
h09b	1.70	128	59	12	3.07	188	210	61

Table 2. Measures of duration (dur) and f0 (mean, range, standard deviation (sd)) (Hz) in human-and cat-directed vocalisations by four domestic cats.

	Human-directed vocalisations				*Cat-directed vocalisations*			
Cat ID	*dur*	*f0 mean*	*f0 range*	*f0 sd*	*dur*	*f0 mean*	*f0 range*	*f0 sd*
c01	21.28	739	267	88	417,06	519	521	158
c02	35.21	605	193	73	11.25	498	387	96
c03	121.08	500	178	56	25.11	324	453	105



	f0 sd	f0 range	f0 mean
■ Cat CDV	120	454	447
■ Cat HDV	72	213	615
■ Human CDS	65	274	232
■ Human HDS	19	96	145

Figure 1. F0 mean, range and standard deviation (sd) in human and cat intra-and interspecific communication.

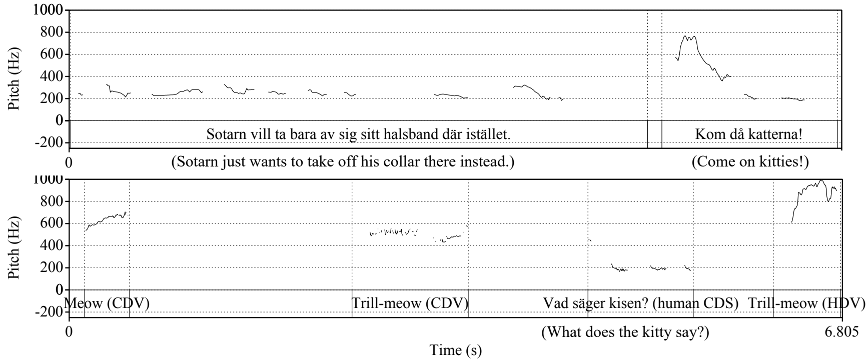


Figure 2. F0 contours of one codeswitching human speaker from human- to cat-directed speech (top) and of one codeswitching domestic cat from cat- to human-directed vocalisation (after having been addressed by his owner) (bottom).

Cat- vs. human-directed vocalisations

The results suggest that cats use higher f0 with humans that with conspecifics. However, only three cats were analysed in this pilot study, so it is hard to draw any general conclusions. Moreover, the two conditions comprised different vocalisation types, which may also have influenced the results. Still, to my knowledge, this is the first direct comparison of f0 in cats' HDV and CDV.

Intra- to interspecific codeswitching

To further exemplify the difference in f0 in intra- and interspecific communication in humans and cats, two samples with human and cat codeswitching (from intra- to interspecific) were analysed (see Figure 2 and Table 3). In both these samples a clear upstep in f0 can be observed in the interspecific communication, indicating that both humans and cats intentionally elevate their pitch in interspecific interactions.

Table 3. F0 (mean, range, standard deviation (sd)) in conspecific (CC) and code-switching (CS) for one human and one domestic cat.

ID	*CC f0 (Hz)*			*CS f0 (Hz)*		
	mean	*range*	*sd*	*mean*	*range*	*sd*
h02a	251	132	30	418	594	
c05	886	389	93	543	235	63

Future research

The use of paralinguistic information and biological codes in human–cat communication needs to be examined further. Future studies include perception experiments with both humans and cats, and with speech as well as cat vocalisation stimuli. Furthermore, acoustic studies of formant frequencies and voice quality in human and cat vocalisations will be carried out in search for more acoustic correlates to paralinguistic information and biological codes.

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