Dog Behavior, 2-2022, pp. 21-28 • DOI 10.4454/db.v8i2.149

New perspectives for quantifying emotions in animals – pilot study

Daniele Gullà[1], Pier Attilio Accorsi[2], Giulia Bompadre[3*]

[1] *National Institute of Biostructures and Biosystems (I.N.B.B.)*
[2] *Department of Veterinary Medical Sciences, University of Bologna, Bologna, Italy*
[3] *Veterinary Expert in Animal Behavior (FNOVI)*

Abstract: The aim of this research was to measure the emotions of animals. For this purpose, some subjects belonging to the canine species have been taken into consideration. Some of them underwent situations that can arouse strong emotions in order to record the changes in their emotional state. The recording of the variation of their emotional state was made by means of special equipment capable of displaying and measuring the energetic state of a body and its variations instant by instant. The tools used for such recordings are already used in the human field. Therefore we wanted to see if what is already validated in the human sphere could also be validated for pets. The first results obtained seem to confirm this possibility.

Key Words: behavior, emotions, dog.

* *Corresponding Author*: giulia.bompadre@gmail.com

Introduction

Well-known researchers of today have ventured into the study of the recognition of the emotions of the dog through facial expressions (Mota-Rojas et al., 2021) or through the detection of biomarkers, such as cortisol (Accorsi et al., 2008); (Zannoni et al., 2020); (Clark et al., 2020); (Ogi et al., 2020) and oxytocin (Ogi et al., 2020); (Mitsui et al., 2011); (Nagasawa et al., 2009). Illustrious authors of the past have ventured into the study of the correlation between reflex movements and the mental or physiological state of a subject. Indeed Aristotle, in his book *De anima*, highlighted the relationship between the movement of living beings and their vitality. In 1863 Ivan Mikhailovich Sechenov, in *Reflexes of the Brain*, pointed out the close correlation between the mental activity, that is thinking, and the muscular activity of a subject. A Few years later Charles Darwin, in *The Expression of the Emotions in Man and Animals*, claimed reflex movements are the visible representation of emotions. Also Konrad Lorenz, in his book *So-called Evil: on the natural history of aggression*, said that measuring the strength and amplitude of a motor reflex provides the measure of aggression behaviour. Despite the above established correlation between reflex movements and the mental or physiological state of a subject, until the 1990s the parameters for investigating motor activity in humans were unknown. In fact, the first researchers Bernstein (1990 and 2004) and Lopez (2002) studied macromotion in the body; and this type of approach has many variables that are difficult to standardize. Only thanks to Minkin starting from 2007, the vestibular reflex has been taken as a reference for the correlation between the movement of a body, its energy state and its emotions. In Minkin & Nikolaenko (2008) we can read: "*In Physics, the oscillatory micromovements of the head on the neck represent a continuum of vibrations whose parameters provide information on the quantitative correlation between movement and energy. The technology allows this type of analysis is based on vibraimaging technology, that is called Vibraimage system. Thanks to this method for the first time the expression of emotional vestibular reflex or reflex of vestibular energy (VER) is coined*" (Minkin et al., 2008). So the research with the Vibraimage System was aimed at recognizing emotional and psychophysiological states. Vibraimage technology (Minkin et al.,

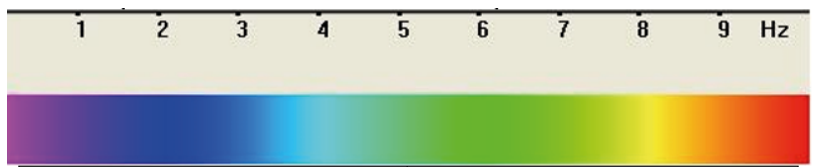
Submitted, 06/11/2022
Accepted, 12/17/2022

2008) provides quantitative information on the movements of any point of the object recorded in a unit of time (periodic movements). The research with the Vibraimage System was aimed at recognizing emotional and psychophysiological states. In fact, Vibraimage System consider emotions and psychophysiological parameters as physical quantities. The algorithms of the determination of the emotional and psychophysiological state in man are based on a statistical apparatus, which considers the movement coordination, the logic of the behavioural psychology and comparative proofs (Minkin, 2020).

The aim of our study was to determine if the Vibraimage tecnology could be an objective method for measuring the emotional state of animals, in particular we focused on anxiety and aggression. If the hypothesis that the vestibular-emotional reflex is informative is correct in man as in animal, then each parameter reflecting head movements should reflect part of its emotional and psychophysiological parameters. So we wanted to investigate whether the Vibraimage method used is a suitable method for measuring the emotions listed above, that is anxiety and aggression, also in animals as in man.

Methods

The principle behind the image analyser is that everything vibrates (Debertolis et al., 2014). These vibrations are not visible, but they are instrumentally measurable (Gullà, 2000). Vibraimage System technology detects the vibrational parameters of amplitude and frequency of each point of the subject. In Vibraimage (Minkin et al., 2008) each pixel corresponds to a point of the subject. Amplitude and frequency parameters of each point of Vibraimage are translated on a monitor screen as a pixels pseudocolor image, and processing parameters of vibration at each pixel we get information about animal's body mobility. Thus, amplitude and frequency parameters of animal body vibrations are determined at each point. The amplitude represents the object-displacement within a certain interval time (10 sec), while the frequency (Hz) corresponds to the number of times of object-displacement in the same interval time. The color/vibration correspondence is shown in Figure 1: Purple color of frequency Vibraimage represents vibration range 0-1 Hz; Blue and Light blue color of frequency Vibraimage represents vibration range 1-4 Hz; Green color of frequency Vibraimage represents vibration range 5-7 Hz; Yellow color of frequency Vibraimage represents vibration range 8Hz; Orange color of frequency Vibraimage represents vibration range 8-9 Hz; Red color of frequency Vibraimage represents vibration range 9-10 Hz.



Colour	Frequency (Hz)
Purple	0,1 – 1
Blue	1 – 3
Light blue	4
Green	5 – 7
Yellow	8
Orange	8,5 – 9
Red	9 – 10

Figure 1. Correlation between frequency in Hz and the pseudo coloured scale.

The system used allows not only to evidence the energetic field, measuring its intensity and frequency, but also to visualize the variations of the energetic field in real time, using radiant horizontal lines of different colour and length. In fact, amplitude and frequency of the energetic vibrations, derived from a body, change continuously. So, in the different parts of a body, the vibrations that it generates vary continuously and rapidly, both for their amplitude, represented by the length of the horizontal lines, and for their frequency, represented by their colour. Thus, the system increases the value information of the primary image providing real time conversion of amplitude and frequency Vibraimages on the external perimeter of the subject, where the size of the linear signals represents the mean amplitude, while its color represents the maximal frequency. All parameters are analysed and memorized every instant by the software of the camera and, at the end of the observation, reports about the spectrum of the vibrations are available. We can briefly state that in each image the horizontal line represents the spectral distribution of the vibrations as a scale of pseudo colour that varies from purple to red, according to the frequency (from 0.1 to 10.0 Hz) of the vibrations. The frequency histogram shows the frequency distribution of each movement within a defined time interval (10 sec). Vibraimage technology provides quantitative information on the movements of any point of the object recorded in a unit of time (periodic movements).

Using the reports (Minkin, 2020), Vibraimage allows to analyse each emotional state in man through different equations. In fact, Vibraimage System consider emotions and psychophysiological parameters as physical quantities. The algorithms of the determination of the emotional and psychophysiological state in man are based on a statistical apparatus, which considers the movement coordination, the logic of the behavioural psychology and comparative proofs (Capitanata et al., 2014; Pagliaro, 2015).

Since in accordance with the principles of kinesiology, the quality of a subject's movements depend on his physiological and psychological state, i.e. emotional, Vibraimage technology considers various emotional parameters, including the state of anxiety and aggression, and is able to measure them thanks to the direct correlation with the real-time variations of periodic movements. In Vibraimage System algorithmic approach for determing the level of each emotion and its calculation equation are given (Minkin, 2020).

Materials

The subjects involved in the research were two owned domestic dogs (*Canis lupus familiaris*) mestizo adults, a male and a neutered female both aged between 4 and 8 years. They were all clinically healthy and not affected by behavioural pathologies. The research was conducted in the Ethology and Animal Welfare lab of the ANFI Service of the Department of Veterinary Medical Sciences and in the open spaces in front of the laboratory itself. The animals involved in this study underwent situations that can arouse strong emotions. The stimuli presented to the animals, in fact, were able to provoke behavioural responses with changes of emotional state. Simultaneously, the variation (frequency and intensity) of the energetic state of the animal was measured. Thus the dogs were videotaped to observe emotions related to social stimuli (presence and visual disappearance of the owner) and related to intraspecific communication in a threatening situation. In every situation, a veterinarian expert in animal welfare identified the behavioural responses with changes of emotional state.

All the test sessions were monitored using Vibraimage technology in order to observe different energetic fields of the dogs corresponding to different emotional states. Moreover, the energetic variation was measured. For every situation tested, the energetic filed measured in real time and the corresponding behavior was correlated with the emotional state of the subject using algorithms integrated into the Vibraimage System.

Test 1 Social stimulus - Owner Separation test

The observation was made with the dog, a female, inside the ethology laboratory. The owner went outside the room and the dog remained without her social figure of reference. The variation of the energetical state of the subject was registered after few seconds, in which the dog was alone and showed typical signs of anxiety (pacing, sniffing under the door and scraping the door with front paws, yelping)[5], and when the owner returns.

Test 2 Intraspecific communication in a threat situation

The observation was made in an outdoor green area with free dogs. Two adult subjects, both males, during their communication showed the classical T position. The T-position is a characteristic position of assertive intraspecific communication (De Keuster et al., 2009). Analysis of the emotional state of one of the two dog was made in this situation.

Results

Test 1 Social stimulus-Owner separation test

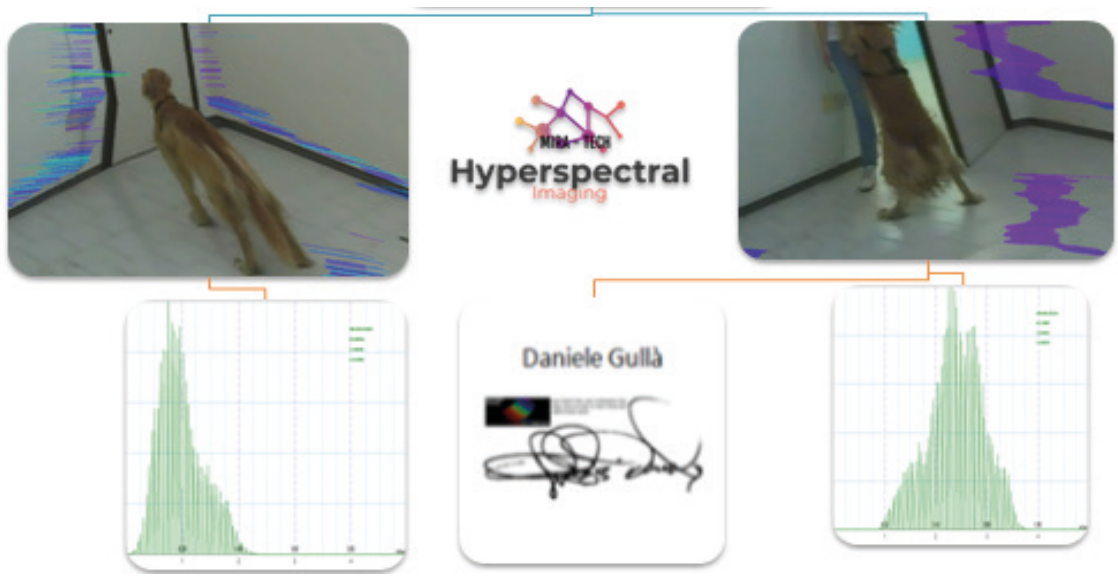


Figure 2. Vibrational analysis during test 1.

Vibraimage registered a strong deformation of spatial domain, with a spectrum of frequencies between 1-4 Hz (purple/light-blue bands) (Fig 4 - left image). The variability of the frequencies together a strong deformation of spatial domain indicate the state of anxiety given by the visual absence of the owner. When the owner entered the laboratory where the dog is (Fig 4 – right image), spectrum of frequency was between 1-2 Hz (purple bands) and showed a lower and wider frequency, and a less deformation of spatial domain. Both graphs in the figure 4 showed a compact energetic spectrum.

Test 2. Intraspecific communication in a threat situation

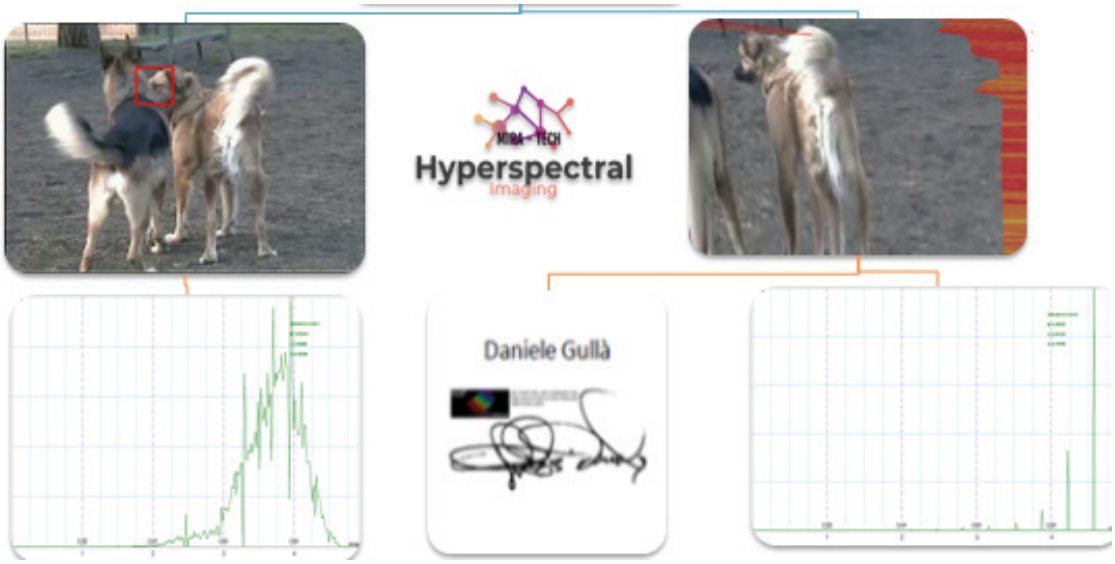


Figure 3. Vibrational analysis during test 2.

The German Shepard showed the T position towards the mestizo dog (Fig.6-left image). Immediately after this behaviour, Vibraimage video-analysis of mestizo dog registered frequencies outside of the range, highlighted by the red blob in the left image and by the distance between the dog's body and the spectral distribution of vibrations with a frequency greater than 10 Hz in the right image. In the corresponding graph, the spectral peak confirms that most of the frequencies were outside the range.

Discussion and conclusion

Thanks to the Vibraimage System we measured the energetic state of an animal body. We know that in humans it is possible to correlate energy frequencies with some emotional states, such as anxiety or aggression (Minkin, 2020). During the owner of separation test, the dog shows a behavior characterized by a state of tension and the search for the owner with an intense olfactory exploration of the door from which the owner came out. This is a typical situation in which most dogs with owners become anxious. In Vibraimage System, tension or anxiety is determined by the ratio of the high-frequency density of the vibration spectrum to the total power in the frequency spectrum of the micromotion of the human head. A high density of high-frequency vibrations characterizes a high value of tension parameter. A similar approach to determining the weight ratio of high-frequency processes is used in the EEG to detect anxiety states (Moretti, 2013). The distribution of tension parameter is relatively close to the normal distribution. In our study, the result of the owner separation test shows us an image and a graph that can be superimposed on what is reported above regarding the anxious state in humans. In fact, although the right figure 2 shows lower frequencies than the left figure 2 as the visual and olfactory contact with the owner caused the dog to reduce its tense and anxious state, the corresponding spectra are still that typical of the state anxious as described in VCE (Minkin, 2020) that is close to the normal distribution. In the right graph, which corresponds to the absence of the owner, the distribution of the spectrum of frequencies is

more shifted to the left, in accordance with the deformation of spatial domain described above.

In the second test, a behavior characteristic of intraspecific communication with assertive modality was filmed, i.e. the display of the T-position by a dog, in this case the German Shepherd, towards the other dog, a mestizo. In Vibraimage System, aggression is determined by frequency histogram and reflects the maximum distribution of the frequency and the standard deviation. Aggression i.e. is the greatest value among all the parameters analyzed by Vibraimage: the higher value of the maximum of the frequency distribution and the higher value of the standard deviation. The proposed formula for determining Aggression is closely correlates with the principle of its definition proposed by Lorenz: "*aggression is proportional to the intensity of reflex movement*s" (Lorenz, 1963). The algorithmic approach to determining the level of aggression was proposed by Minkin in 2014 and the distribution obtained by Vibraimage system program is rather asymmetric and has a center shift towards lower values (Minkin, 2020). In our study, the result of the second test shows us an image (Fig. 3 left) in which a red box appears. The red box indicates that the recorded frequencies are out of range, i.e. they exceed 10 Hz, and this is in accordance with the underlying emotion of aggression as defined by Minkin in 2014. In the right image of the same figure, the spectral peaks, for the most part around 10 Hz (red color), appear not in continuity with the shape of the body due to a computational delay of the system, for a latency between the calculation speed and the intermittent movement of the body. This phenomenon in Vibraimage is observed when there is a strong stress, and the situation in which the mixed breed dog finds himself justifies widely this image (Fig. 3 right). Also the corresponding distributions in both graphs are rather asymmetric and have a center shift towards lower values, in accordance with the above. We can say that the activation of the higher frequencies is in accordance with an emotion of aggression (Minkin, 2020) and, both in humans and in dogs, aggression has overlapping spectra for qualitative and quantitative characteristics.

These first and few data collected show us that the Vibraimage system for measuring the energy state of a person could also be used for the measurement of the energy state of an animal. Furthermore, with regard to the emotional parameters taken into consideration (anxiety or tension and aggression), we can observe the same vibrational characteristics in man and dog. Therefore also for animals, and in particular for dogs, it is possible to speak of *"emotional vestibular reflex" or "reflex of vestibular energy" (VER)*, which indicates the correlation between the movement of a body, its energy state and its emotions. This expression was coined in 2006 by Minkin, and until today it has been referred only and exclusively to man.

The vestibular system is used for the study of movement analysis, and it is considered a model of micromobility because it is less by variables and therefore more advantageous than the study of other reflex movements. The emotions of dog, generated by stimuli with social value (owner separation and T-position), were translated by Vibraimage System in images and measured on a par with physical quantities: amplitude and frequency of micro-movements of the vestibular reflex.

The work could lay the foundations for the observation of other emotional correspondences between man and animals. However, the Vibraimage system has not been validated in the animal field. The results obtained, in fact, are completely partial both for the number of subjects involved and for the number of tests carried out. Furthermore, the data collected were not compared with the levels of those biomarkers that are known to be correlated to changes in the subject's emotional state both in humans and in animals.

Ethical Statement

For the present study were observed and video taken dogs in the presence of their owners. A veterinarian expert in animal welfare was constantly present during all the observations and video recordings. Therefore the present study was determined to be exempt from institutional commissions for animal welfare.

Bibliography

Accorsi P.A., Carloni E., Valsecchi P., Viggiani R., Gamberoni M., Tamanini C., Seren E. Cortisol determination in hair and faeces from domestic cats and dogs. Gen Com Endocrinol 155(2): 398-402; 2008.

Aristotele, De anima I; IV sec a.C. Teubner, Lipsiae; 1884.

Bernstein N.A. Motion Physiology and Activity [in Russian], Nauka, Moscow; 1990.

Bernstein N.A. Biomechanics and Physiology of Motion [in Russian], MPSI, Moscow; 2004.

Capitanata R., Gullà D., Pellizzon M., Richeldi F. Video psychophysiological analysis of energy levels before and after the music 432 hz played by rino capitanata IPERLAB; 2014.

Clark S.D., Smidt J.M., Bauer B.A. Therapy Dogs' and Handlers' Behavior and Salivary Cortisol During Initial Visits in a Complex Medical Institution: A Pilot Study. Front Vet Sci. Sec Animal Behavior and Welfare; 2020.

Darwin C. The Expression Of The Emotions In Man And Animals;1872.

De Keuster, T. and Jung, H. Aggression toward familiar people and animals. In BSAVA manual of canine and feline behavioural medicine (pp. 182-210). BSAVA Library; 2009.

Debertolis P., Gullà D., Richeldi F. Archaeoacoustic analysis of an ancient hypogeum using new TRV camera (Variable Resonance Camera) technology. A new method of analysis in archeoacoustics for a best archaeological knowledge ScieConf; 2014.

Gullà D.,The BFS (Bio-Frequency-Spectrum): the Physical-Theoretical Analyses of Biosystems and New Technologies for Bio-regulation, Proceedings of "BIO-SPECTRUM MEDICINE" Ediz. ASP International; 2000.

Lopez E. M. A Graphic Technique of Personality Research [Russian translation], Rech, St. Petersburg; 2002.

Lorenz K. So-called Evil: on the natural history of aggression; 1963.

Minkin V. A. Vibraimage [in Russian], Renome, St. Petersburg; 2007.

Minkin V.A. and Nikolaenko N.N. Application of Vibraimage Technology and System for Analysis of Motor Activity and Study of Functional State of the Human Body. Biomedical Engineering. Vol.42, No.4: 196-200; 2008.

Minkin V.A. Vibraimage, Cybernetics and Emotions. Ed. Renome. pp 13-90; 2020.

Mitsui S., Yamamoto M., Nagasawa M., Mogi K., Kikusui T., Ohtani N., Ohta M. Urinary oxytocin as a noninvasive biomarker of positive emotion in dogs. Hormon Behav 60:239-243; 2011.

Moretti D. V. EEG Upper/low Alpha Frequency Power Ratio Relates to Temporo-parietal Brain Atrophy and Memory Performances in Mild Cognitive Impairment,Front. Aging Neurosci. 10: 2013.

Mota-Rojas D., Marcet-Rius M., Ogi A., Hernández-Ávalos I., Mariti C., Martinez-Burnes J., Mora-Medina P., Casas A., Domínguez A., Reyes B., Gazzano A. Current Advances in Assessment of Dog's Emotions, Facial Expressions, and Their Use for Clinical Recognition of Pain. Animals(Basel) 11(11):3334; 2021.

Nagasawa M., Kikusui T., Onaka T., Otha M. Dog's gaze at its owner increases owner's urinary oxytocin during social interaction. Hormon Behav 55 (3): 434-41; 2009.

Ogi A., Mariti C., Baragli P., Sergi V., Gazzano A. Effects of stroking on salivary oxytocin and cortisol in guide dogs: Preliminary results. Animals. 10:708-713; 2020.

Pagliaro G. Energia materia e mente creatrice. Scienza e Conoscenza, ISSN 1720-9986; 2015.

Sechenov I.M., "Reflexes of the Brain"; 1863.

Zannoni A., Pietra M., Gaspardo A., Accorsi PA., Barone M., Turroni S., Laghi L., Zhu C., Brigidi P., Forni M. 2020. Non-invasive Assessment of Fecal Stress Biomarkers in Hunting Dogs During Exercise and at Rest. Front Vet Sci. 7:126; 2020.

Nuove prospettive per quantificare le emozioni negli animali: uno studio pilota

Daniele Gullà[1], Pier Attilio Accorsi[2], Giulia Bompadre[3*]

[1] *National Institute of Biostructures and Biosystems (I.N.B.B.)*
[2] *Department of Veterinary Medical Sciences, University of Bologna, Bologna, Italy*
[3] *Veterinary Expert in Animal Behavior (FNOVI)*

Sintesi

Con la presente ricerca ci si è posti l'obiettivo di quantificare, ovvero misurare, le emozioni negli animali.

A tal fine alcuni soggetti di specie canina sono stati sottoposti a situazioni in grado di suscitare forti emozioni per poi registrare le variazioni quantitative del loro stato emozionale. La registrazione della variazione dello stato emozionale è stata effettuata mediante speciali apparecchiature in grado di visualizzare e misurare istante per istante lo stato energetico di un corpo e le sue variazioni. La tecnologia utilizzata per tali registrazioni è già ampiamente utilizzata in campo umano. Il sistema Vibraimage, infatti, è in grado di rilevare e misurare diverse tipologie di emozioni nell'uomo grazie a specifici algoritmi codificati. Abbiamo quindi voluto verificare se quanto già validato in ambito umano potesse essere valido anche per gli animali. I primi risultati ottenuti sembrano confermare questa possibilità. I dati raccolti mettono in luce alcune corrispondenze emotive tra l'uomo e gli animali relativamente ai due stati emozionali indagati: lo stato ansioso e l'aggressività. Tuttavia, l'esiguo numero di soggetti coinvolti nello studio e l'assenza della rilevazione dei biomarker, notoriamente correlati a variazioni dello stato emozionale sia nell'uomo sia nel cane, fanno sì che tale sistema Vibraimage non possa ancora essere validato per la specie canina.