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Inherent emotional feature extraction of neonatal cry

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Abstract: Mining the inherent emotional feature of life is of great significance, and the method to extract the inherent emotional feature with a small number of samples is explored based on neonatal cry in this study. The minimum embedding dimension is taken as the nonlinear feature representing nervous system activity and emotion, and is also analyzed at multiple scales. It is found that the minimum embedding dimension of pain cries is higher than that of sad cries, and has a certain change rule in different frequency bands. The results are consistent with related emotional research of brain nerve activity and the characteristics of the pain cry, and may help in the study of information ecology of the brain in different emotions.

Keywords: inherent emotional feature extraction; nonlinear method; minimum embedding dimension; neonatal cry

1. Introduction

How to extract inherent emotional feature of life with a small number of samples? Due to the purity of neonatal model, neonatal cry is selected. And the nonlinear method is used to explore the small-sample-set way of inherent emotional feature extraction in this study.

2. Materials and Methods

Individuals have different complexity in different emotional states. In this study, 150 labeled segments of neonatal cry audio are downloaded from freesound.org, including pain, angry, hunger and sad labeled cries. The minimum embedding dimensions of the cries are extracted by Cao's method to reflect the complexity of the system, as a whole and in each frequency bands after wavelet decomposition by the db7 wavelet.

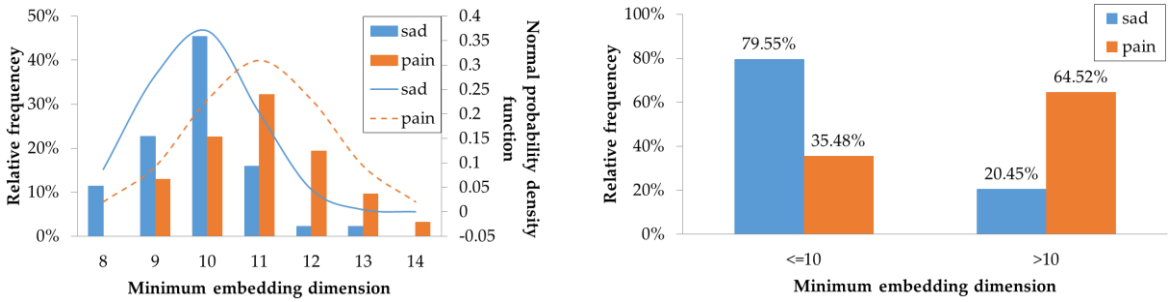
3. Results

The minimum embedding dimensions of the cries due to different reasons are different, as is shown in Table 1. The minimum embedding dimension of pain cries is the highest, and that of sad cries is the lowest.

Table 1. Averaged minimum embedding dimensions for 150 labeled segments of neonatal cry audio.

Label	Pain	Angry	Hunger	Sad
Number of segments	31	48	27	44
Averaged minimum embedding dimensions	11.00	10.37	10.19	9.81

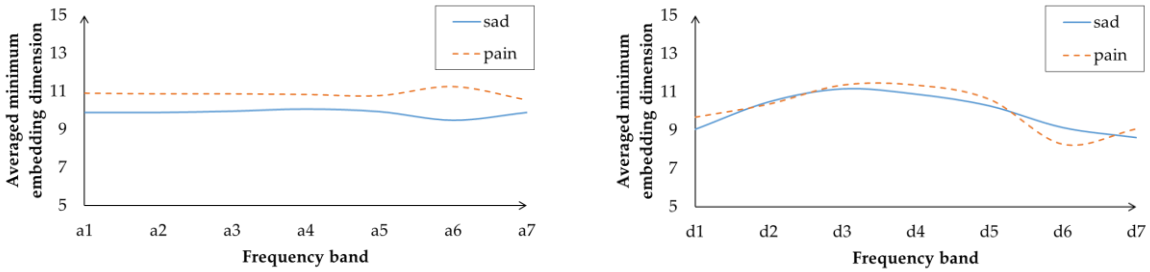
The distribution of extracted minimum embedding dimensions of 44 segments of pain cries and 31 segments of sad cries is shown in Figure 1, with two high probabilities around 11 and 10 respectively. Thus, it can be deduced that the complexity of the individual nervous system in the state of pain is higher than that in the state of sadness.



(**a**) (**b**)

Figure 1. (a) The histogram and the normal probability density function of minimum embedding dimension of 44 pain-labeled and 31 sad-labeled audio data segments; (b) The bounded histogram of minimum embedding dimension of 44 pain-labeled and 31 sad-labeled audio data segments. The minimum embedding dimensions of pain cries and sad cries have high distribution probabilities around 11 and 10 respectively.

The averaged minimum embedding dimensions of pain cries has a large decrease in the d6 frequency band, as is shown in Figure 2, which can indicate that the systematicness of the detail signals of pain cries shows a significant decrease in the d6 frequency band.



(**a**) (**b**)

Figure 2. (a) Averaged minimum embedding dimensions of the approximation signals of cries in different frequency bands and different states; (b) Averaged minimum embedding dimensions of the detail signals of cries in different frequency bands and different state. The averaged minimum embedding dimensions of approximation signals of pain cries are universally higher than that of sad cries, while those of pain cries' detail signals show a large decrease in the d6 band, corresponding to the frequency band between 0.34 KHz and 0.69 KHz.

4. Discussion

For both positive and negative emotions, there are different patterns of activity in the brain [1]. Activation and pleasantness are dimensions of the conscious experience closely related to the nervous system [2, 3]. Individuals are in a state of tension and alertness during pain [4], so in the two-dimensional structure of emotion, the activation of the nervous system is high in pain, and relatively low in the sad state. Pain causes increased activity in the nervous system, leading to increased complexity of the individual life system [5-7]. And sadness causes reduced activity in the brain and reduced complexity [8-10]. This is consistent with the results obtained in this study. This consistency indicates that the minimum embedding dimension of cries can be used as the feature representing the individual emotional state and the complexity of the nervous system activity.

The crying signal produced by pain begins with a strong and long high pitched pronunciation [11, 12], ending in a melodic signal. The initial strong and high pitched cry may be regarded as a kind of warning signal. So the minimum embedding dimension decreases of the pain signals in the d6 frequency band may be due to the increase of the warning signals contained.

By mining the inherent features of neonatal cries, it may help in the study of information ecology of the brain in different emotions. Besides, the machine learning with small sample set may be easier if some knowledge-based rules are set, considering the benefit that the system complexity bring to the inherent emotional features extraction.

5. Conclusions

In this study, the nonlinear method is used for mining the features of neonatal cries, which can be used to represent the state of the human body. It is found that the minimum embedding dimensions extracted from cries caused by different factors are different. The minimum embedding dimension of pain cries is higher than that of sad cries. This finding is consistent with previous studies of emotion and nervous systems. The minimum embedding dimension of cry signals in different frequency bands is extracted. The multi-scale minimum embedding dimension of cries in pain is found to be changed under a certain rule. This is consistent with previous studies of pain-related cries that contain a strong pronunciation. It is suggested that the minimum embedding dimension of cries can be used as a feature to characterize the emotional state of the individual and the complexity of the nervous system. It is also proved that the inherent emotional feature, consistent with emotional studies, is extractable based on a small number of samples by the nonlinear method.

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Conflicts of Interest: The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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