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ARTIFICIAL NEURAL NETWORK BASED MODEL FOR THE CRISPNESS IMPRESSION OF THE POTATO CHIP SOUND

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Sound design and quality are becoming increasingly important for the food industry. The sounds which occur during biting the food or the packaging based sounds are designed to convey the product related information to the customer. Particularly such kind of sounds are important regarding the brand design. Previous studies noticed that the chewing sounds can influence the perceived food crispness. The aim of this study to predict the perceived crispness of the chips sounds using artificial neural networks (ANN). The chip bite sound has very impulsive type complex character. In a listening test, the recordings of the sound of 5 chips and filtered variations of the recordings were presented to the subjects and they evaluated the perceived crispness of the chip bite sounds. Psychoacoustical parameters which are based on temporal and spectral characteristics of the chip bite sounds were used as input parameters for the developed ANN. The results of the study was compared with previous food sound design studies.

Keywords: Food sounds, multisensory perception, crispness, sound quality, sound design

1. Introduction

The product sound design becomes more and more important. Over the last few decades, there is an important number of research on vehicle and household appliance sound quality [only few examples: 1, 2, 3]. Food industry follows this trend. Besides of the visual image of the packaging, the sound of packaging is in the focus of product designers. For example the opening sound of the bag of the chips or the opening sound of the bier bottles are designed very carefully. Even the shape of the bottle is audible, when we hear the pouring sound of the liquid. Therefore most of the food manufacturers try to define brand sounds for their foods. Another important food sound design example is the bite sounds which occur during the biting a biscuit or chip. The objective of this study is to develop an artificial neural network based model for the perceived crispness of the potato chip sounds. In our previous study we have conducted listening experiments and the crispness of chip sounds were evaluated [4]. We use the perceptual data from our previous study to develop the NN. Therefore the descriptions of the experiment (stimuli, subjects, experimental procedure, and results of the experiments) is taken from our previous study [4]. In this perceptual experiment, recordings of the sound of 5 chips and filtered variations of the recordings were presented to the subjects. Then, a link between the perceptually important signal properties and the crispness was established. Developing an artificial neural network, the prediction of the perceived crispness of the chips was automatized.

2. Experiment

2.1 Stimuli

Sounds of five different chips were recorded using a binaural headset (HEAD acoustics). The experimenter made a single bite with his front teeth and then close his mouth (similar procedure as in [5]). This study concentrates on bite sound rather than the chewing sound taking into that the bite sound is the dominant sound regarding the crispness. He tried to make comparable bite movements in each case. All recordings were conducted in the anechoic chamber of Technische Universitaet Dresden. Then additional sound stimuli were generated by filtering important frequency components (e.g. tonal components using band pass filters, high or low frequency ranges using high or low pass filters). Particularly the variation of the high frequency content of the sounds was important for the study taking into account the results of the previous studies in this field.

2.2 Subjects

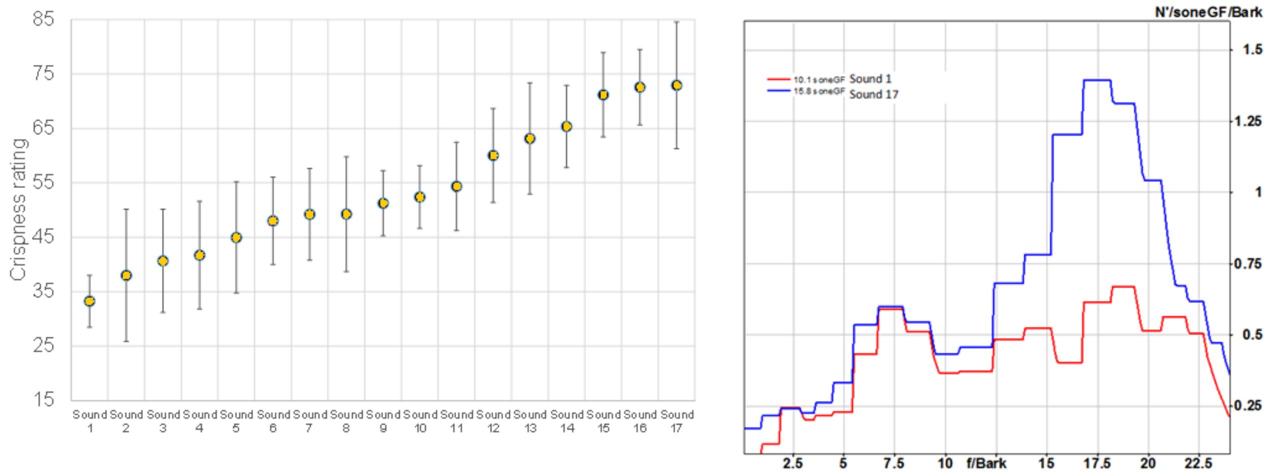
Twenty participants (12 females and 8 males) took part in the listening experiment. Age of the participants varies between 20 and 56 years old. The participants are naïve and don’t have any acoustic or food engineering background. They were paid for their participation on an hourly basis. All participants reported that they have normal hearing.

2.3 Experimental Setup and Procedure

HEAD acoustics HA II.1 headphones were used to present the binaurally recorded sounds and modifications. An aurally-accurate reproduction was guaranteed using a PEQ IV equaliser. The experiments were conducted in a sound-attenuated room. Sounds were presented in a random order and two times. The participants were asked to evaluate the crispness of the sounds on a quasi-continuous scale (not at all, slightly, moderately, very, and extremely). The length of the slider was 100 mm with a resolution of 1 mm. The score on this scale was equal to the distance (mm) from the left end of the bar. A graphical user interface in MATLAB was implemented for the evaluation experiments. The experiment lasted approximately 36 Minutes including a training and instruction session. In the training phase, all of the participants were presented with different combinations of stimuli from across the full stimulus range, and they were then familiarized with the procedure of the experiment.

2.4 Results of the Experiment

The crispness judgments for the potato chip sounds were averaged, and the mean scores are shown in Figure 1a. The analysis results for the loudness of the most crispy and softest potato chip sounds (Sound 17 and Sound 1) are shown in Figure 1b.



a) b)

Figure 1: a) The crispness ratings of the stimuli, b) The loudness vs. bark analysis of the chip sounds 1 and 17 .

It is evident that the overall loudness and the high frequency content (sharpness) of the chip sounds have strong relationship with the crispness perception. Taking into account this aspect, an index, which is based on psychoacoustical parameters was developed to estimate the perceived crispness of the chip sounds. The developed index is based on the multiplication of both psychoacoustical parameters (Crispness Index = Loudness * Sharpness). The Zwicker model was used for the calculation of the loudness (ISO532B [6]), the Aures models were used for the calculation of sharpness [7].

3. Development of the ANN

The developed artificial neural network is a two-layer feed-forward neural network. Two psycho-acoustical parameters, such as loudness and sharpness, are used as input parameters. The Bayesian Regularization method was used as training algorithm. The performance estimation is based on the Mean Squared Error. Annoyance ratings of the 17 stimuli is presented in a box plot in Figure 2. The results of the listening test are shown in red and the estimations of the developed neural network are shown in purple. The estimations are in good agreement with the listening test results.

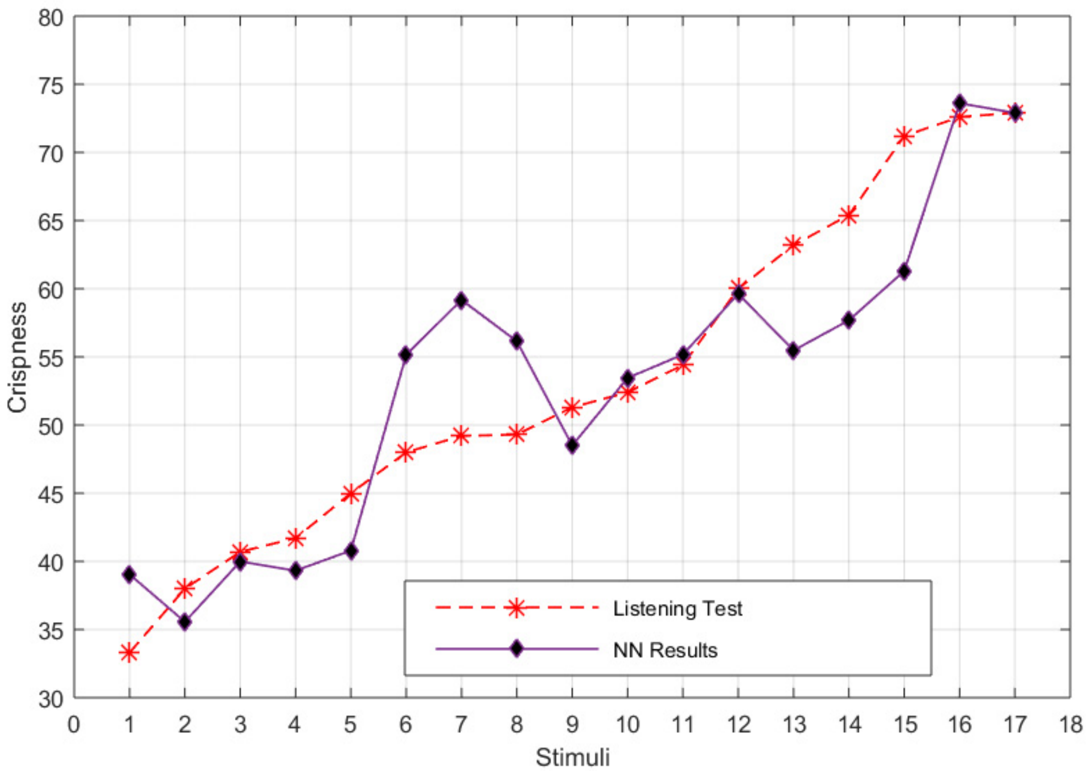


Figure 2: The comparison of the listening test results and NN estimations.

To check the quality of the developed neural network, the estimations of the developed index are compared with the estimations of the NN. The comparison results are presented in Figure 3. The estimations of the developed index are shown in blue. It is observable that almost both index and the NN estimations match well with the listening test results. The differences between the NN estimations and the index estimations are very small. The NN estimates the perceived crispness of the stimuli 16, 10, and 11 slightly better than index. However the index estimates the perceived crispness of the stimuli 4, 5, and 15 slightly better than the NN.

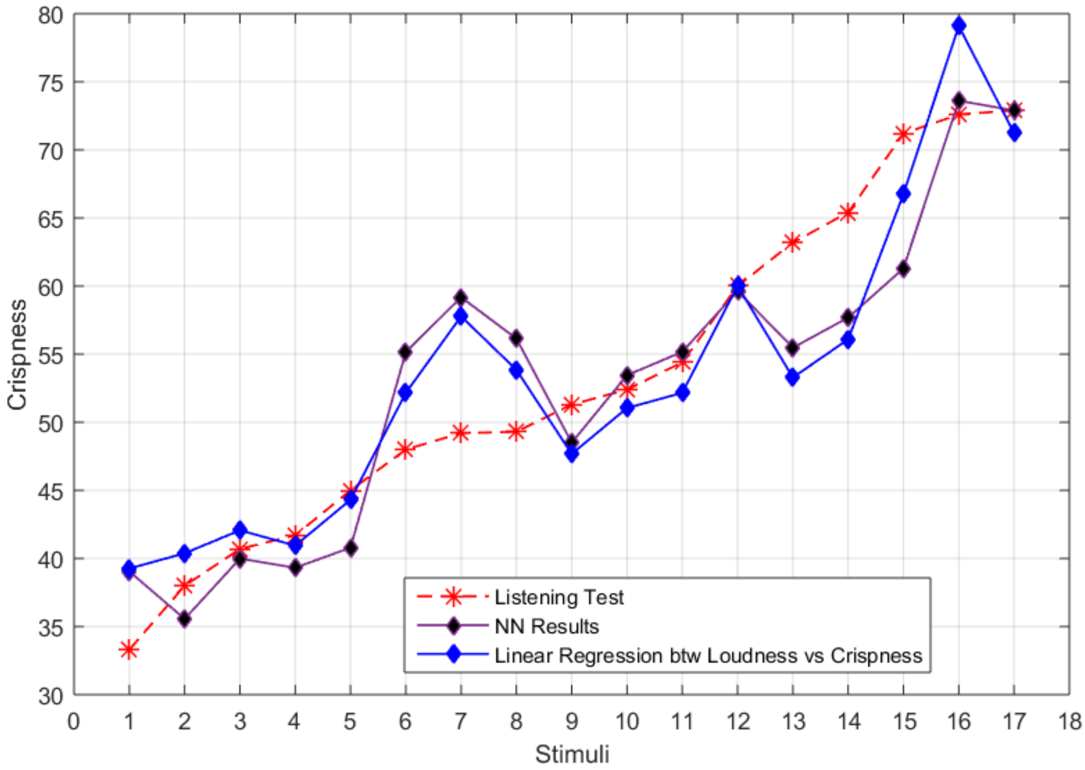


Figure 3: The comparison of the listening test results, index and NN estimations.

4. Discussion and Conclusion

The results of the study show that the developed NN estimates the perceived crispness of the chips very well. The performances of the crispness index and the NN are almost comparable and good. An important reason for this similarity is the limited number of the inputs for the NN. In this study only two input parameters, such as loudness and sharpness, were used as input parameters for the NN. Possibly more input parameters can improve the performance of the NN. On important aspect of the bite sound is its temporal character. Future investigations are planned to determine the influence of the time dependent sound pressure level, the time dependent loudness or the time dependent sharpness characteristics of the bite sound on the crispness impression and increase the input parameters of the NN.

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