Abstract

The acoustical signals are information carriers and the sound of a product is a hint of its quality. We communicate with industrial products in various situations and their sound inform us about the product, its operating condition or its quality. In some cases the product sounds can evoke emotional associations. For example, the roaring sound of a vehicle can be associated with the sportiness or the rattle of an oldtimer can be associated with the nostalgia. Not only the sounds of the industrial products, but also the sounds of the food deliver us various information. Earlier life (eating) experiences play an important role on this issue. We learn in our early childhood the connection between the acoustical parameters and the nutritional properties. The objective of this study is to investigate the relationship between the properties of the chip bite sound and the perceived crispness. In an experiment, the crispness of chip sounds were evaluated. In this 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. **Keywords**: Food, nutrition, sound, design, quality.
The Quality of Potato Chip Sounds and Crispness Impression

1 Introduction

Branding becomes more and more important for different industry branches. Product functionalism and safety are central design issues. However technological differences between the products are becoming less and less. Therefore manufacturers try to find not only technological innovations but also aesthetical and emotional aspects to design new products which differ from the competitive products. In this case product sounds allow designers a lot of new possibilities. Product sounds can deliver in very short time span the important information to the product users. They can evoke easily different emotions, give positive associations related to the product and make easier to design the typical products (identifiability and familiarity). Typicality is an important aim of the product designers and it provides the product to get an artistic identity in the market between the same classes of products and also it may form of enthusiasts group for the product. Therefore automotive manufacturers and household appliance manufacturers make immense efforts for to design their product sounds and sound branding. Food industry has also noticed that nutrition related sounds can be very important for not only branding but also to deliver food related information in an effective way.

As early as 1980s, some researchers noticed that chewing sounds can influence the perceived food crispness [1]. There is a strong association between the crispness and food’s freshness which is directly related to the perceived quality of the food. In the following years, the researchers confirmed these results and found that the loudness and frequency content of the sound have influence on the perceived crispness [2, 3, 4, 5, 6, 7, 8]. However the results of the studies show that auditory and tactile information can be completely redundant [1, 2]. Another study showed that airborne sound is much more important for the crispness perception than structureborne sound [8]. The aim of this study is to determine the psychoacoustical properties which influence the crispness perception. Therefore the sounds of 5 different chips were recorded. Using the original and filtered sounds, a listening experiment was conducted to investigate the correlation between the psychoacoustical properties and the crispness impression.

2 Listening Experiment – Perceptual Evaluation of Potato Chip Sounds

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 [2]). 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) (Rohrmann, 1978 [9]). 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 in (detailed information provided in Altinsoy, 2013 [10 and 11]). 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.

3 Results

The crispness judgments for the potato chip sounds were averaged, and the mean scores are shown in Figure 1. The analysis results for the loudness of the most crispy and softest potato chip sounds (Sound 17 and Sound 1) are shown in Figure 2. 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.
Figure 1: The crispness ratings of the original and modified potato chip sounds (100: extremely crispy, 0: not at all)

Figure 2: The loudness vs. bark analysis of the chip sounds 1 and 17.
The developed index is based on the loudness and the sharpness of the sounds. The Zwicker model was used for the calculation of the loudness (ISO532B [12]), the Aures models were used for the calculation of sharpness [13]. The developed index is based on the multiplication of both psychoacoustical parameters (Crispness Index = Loudness * Sharpness). A regression analysis between the developed index and crispness ratings resulted in a correlation coefficient of $r^2 = 0.87$ (Figure 3).

![Figure 3: The correlation between the crispness ratings and the index.](image)

4 Conclusions

The results of this study show that the loudness and the sharpness are two important parameters of the chip sounds which influence the perceived crispness. These results are in line with the results of the [1, 2, 4]. Taking into account these results, a crispness index was developed which consists of the multiplication of both parameters. Chip bite sound is an impulsive type sound. Therefore the loudness and the sharpness of the sound are highly time dependent. Future investigations are planned to investigate if the temporal features of the loudness and sharpness can better describe the crispness perception.
References


