Exploration on the Development of Comfort and Stability of Bone Conduction Earphones

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***Abstract*—In order to simplify the product iteration process and reduce capital investment, it is necessary to design a set of method models for quantitative analysis of the stability and comfort of bone conduction headphones. Use the heart rate variability (HRV) and mechanical mobile simulation platform to eliminate the interference of subjective feelings. For illustration, a bone conduction earphone example is utilized to show the feasibility of the model in solving the balance of comfort and stability. The analysis of the example shows that after applying the quantitative analysis plan, combined with actual research, it is possible to effectively demonstrate the mechanical interval that satisfies the stability and comfort of the headset. This quantitative analysis solution based on objective standards can effectively solve the stability and comfort extension analysis of headset products in the iterative optimization process, which can reduce the cost and time of enterprise research and development.**

***Index Terms*—quantitative analysis, comfort, stability, heart rate variability, bone conduction earphones**

I. Introduction

In the process of iterative optimization of headphones, companies need to evaluate the comfort and stability of the designed headphones, and then improve the structure of the headphones. At present, companies use a large number of users to wear and give feedback to collect information. This method is not only too subjective, but also costly in time and money. In the study of clothing comfort, a method of using heart rate variability (HRV) for comfort determination was developed. By designing motion simulation platforms with different directions and speeds, the stability changes during the wearing of the headset can be simulated. Based on the two methods of heart rate variability and exercise simulation platform, the balance between the stability and comfort of the headset is jointly explored.

II. Mechanical Data Collection

A. Pressure Adjustment Device

A telescopic rod is fixed to the two ends of the elastic metal of the earphone, and the deformation of the elastic metal is changed by the length of the telescopic rod, thereby changing the clamping force of the earphone.

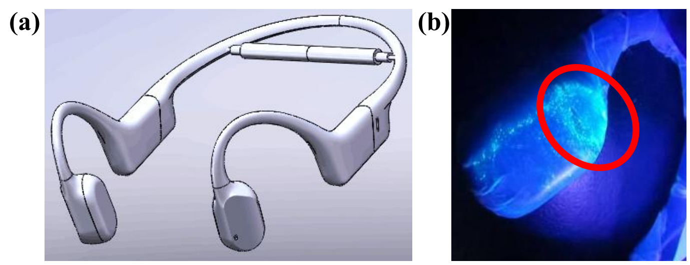

Figure 1. (a) Pressure adjustment device; (b) Fluorescence detection.

B. Pressure Area Fluorescence Detection

The earphones were actually worn to carry out the fluorescent marking experiment of the contact points. The main contact positions of the earphones and the human body were determined and pressure sensors were placed.[1]

C. Sensor Construction

A membrane pressure sensor is used to collect pressure data. As a flexible material, skin needs a thin plate to avoid changes in force caused by skin deformation. Since the sensitivity of the resistive sensor is related to its pressure area, the gasket can collect the force on the sheet to one point, thereby improving the accuracy of the sensor.

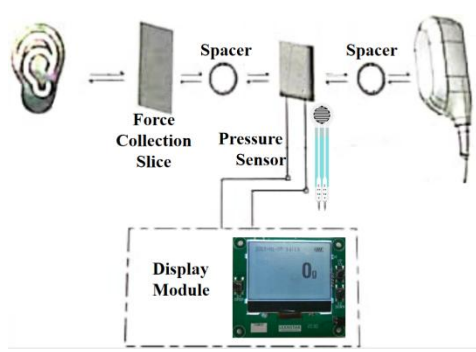

Figure 2. Design of Pressure Sensor.

Funding provide by RAPIDAMIC LAB & Aftershokz.

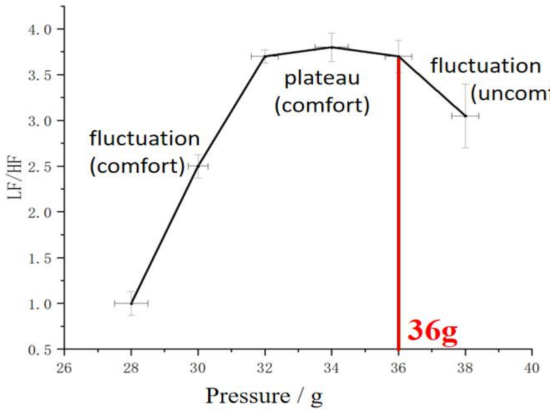

Figure 3. HRV result for AS800.

III. Comfort Analysis

A. Heart Rate Variability

Heart Rate Variability (HRV) analysis is a widely recognized non-invasive quantitative index for evaluating autonomic nervous activity. The change of the human mental state is controlled by the brain's nerve center. The use of brain wave indicators can realize the quantitative expression of sensation to a certain extent, and make up for the subjective uncertainty evaluation of wearing pressure and comfort. [2]

The HRV index LF/HF reflects the balance of tension between the sympathetic and parasympathetic nervous systems. When the skin feels pressure, the HRV index will fluctuate. When the pressure is within the body's adaptation range, the index tends to stabilize. When the pressure exceeds the adaptation range, the data will fluctuate a second time.[3] Collect HRV time domain data through heart rate belt and watch, convert it to frequency domain data (LF, HF, LF/HF) through matlab, and record the feedback on comfort.[4]

B. Comfort Test

For illustration, AS800 from Aftershokz is utilized as an bone conduction earphone example to show the result of HRV result. The POLAR A370 heart rate monitor is used to collect and process data. When the pressure is less than 36g, the headset is in the wearing comfort range.

IV. Stability Analysis

A. Simulate Mobile Platform

Mecanum wheels and differential lift rods are used to simulate the real running state under XYZ three-dimensional conditions. Wear a headset with a pressure sensor on simulated silicone human head models, and simulate different motion situations through a motion platform. Detect the number of sensors during exercise to monitor stability.

B. Stability Test

Record the pressure at rest during the experiment, observe the pressure change during the movement through the pressure sensor. If pressure is 0, it is considered that a certain direction is contactless. The clamping force of the earphone

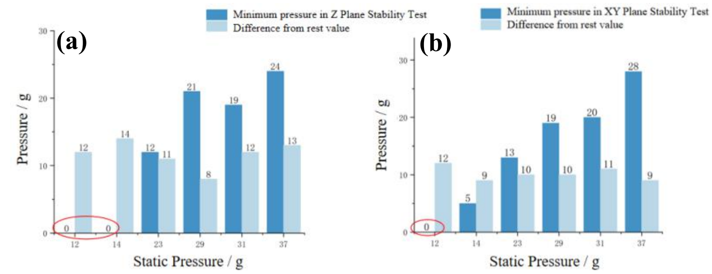

Figure 4. Stability results for AS800.
(a)The Z plane stability result; (b) The XY plane stability result.

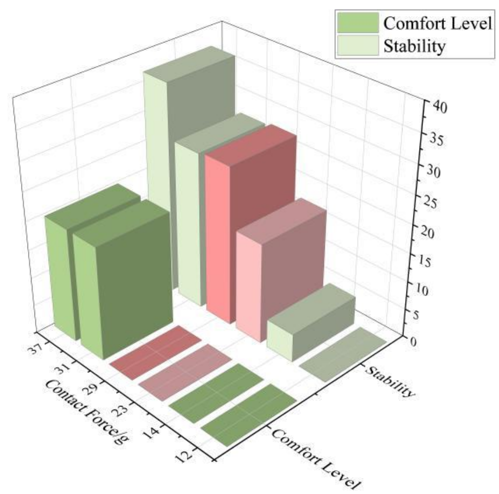

Figure 5. Stability and comfort results.

is changed by the pressure adjustable device, and many experiments are carried out to determine the pressure range that makes the earphone wear stable.

When the static pressure is less than or equal to 14g, the minimum value of the fluctuating pressure will reach 0g. The headset is unstable without contact with the skin.

C. Analysis of extraction experiment results

Comfort and stability are balanced when the contact force is between 14 and 36 grams.

V. Conclusion

The proposal of this solution can not only standardize data processing in terms of comfort and stability, but also accelerate the process of iterative optimization of headphones. In the optimization, this solution can feedback the shortcomings of the headset structure, which is beneficial to the technicians to improve the comfort and stability of the headset, which is of great significance and practical value.

It is planned to design a higher-precision pressure adjustment and detection device in the future. At the same time, use the human head database to establish an accurate simulation model for pressure prediction. For the analysis of big data, machine learning is used to predict the results under different stress conditions.

Acknowledgment

The authors wish to thank L. Ma and Y. Wei for the assistance with the sensor testing.

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