

# Sound Through Bone Conduction in Public Interfaces.

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## ABSTRACT

Noise level in public spaces sometimes makes impossible to focus on particular sound information. In other cases, such focus is needed even when environmental sound information is also important. In this paper, we describe the use of bone vibration as an applicable technology in both public and private interfaces, when environment sound information or environmental sound contamination are regarded as important factors.

## Keywords

Bone vibration, sound transduction, public interfaces, noise level.

## INTRODUCTION

Although the idea of conveying sound through bone vibration has been in use for quite a while in specific situations, this technology seems to escape the mainstream use in public interfaces.

The possibility of a second “channel of sound” can be particularly useful in situations where: a) the environment noise level is high or sound contamination is to be avoided; b) the environment sound information is important; c) the usual private sound interfaces (such as mobile phones) are disturbing to the environment or if freedom of movement is needed.

In these situations, different implementations of a bone vibration transducer would be extremely useful, and would solve or avoid the mentioned problems. For example, a small headpiece attached to eyeglasses or a headset (with no obstruction to the ear) would solve b) and c), and a device embedded in a seat’s headrest or a surface where one could lean one’s head in a public space (such as an elevator) would solve a).

## EXISTING APPLICATIONS

Sound transduction through bone conduction has been used for more than 50 years in subjects with certain types of hearing impairment. Specifically, cases where profound damage to the middle and/or outer ear exists, usually classified as “conduction loss”, but where the cochlea is still intact are good candidates for the use of hearing aid devices that use this technology. Bone conduction devices have been tested since the 16<sup>th</sup> century. The first practical one was the 1879 Rhodes Audiophone which used a vulcanite fan to pick up air vibrations and transmit them to the teeth. Electric bone conduction hearing aids appeared in 1923. Although today most conduction hearing losses are corrected surgically, the technology is still available for other applications.

Such is the case of bone conduction headsets for military applications, where environment sound information is extremely important. A similar implementation is used by divers, where the transducer is located either in the mouthpiece or as part of the mask, behind the ear.

## PHYSIOLOGICAL BASIS

The inner ear is one of nature’s more remarkable transduction devices. In particular, the snail-shaped cochlea serves to transduce sounds into electrical signals that are ultimately encoded by the brain. The bone transducer transmits sound through bone vibration, to the cochlea in the inner ear, bypassing the middle and outer ear.

The best place to “interface” with the bone is on the mastoid section of, which is the bone behind and above our ear. Although the back of the head is also a good point, there is a loss of signal of about 50db. Also, intervening tissue can account for a loss in the acoustical signal of as much as 10-20dB.

## THE PROJECT

We decided to build a prototype of a bone conduction device, to test the possibilities of this technology in day-to-day applications. Such device would be mounted in a chair with a headrest, and would connect to an external audio source. We were looking to build a cheap prototype with

off-the-shelf parts if possible. The goal was to hear a clear audio signal at a proper level when resting the head on the headrest. We thought of this implementation as possible in a car or a plane environment, where all the mentioned situations (a,b and c) exist.

### THE PROTOTYPE

Our prototype consisted of a couple of coil transducers taken from Tiger Electronics Sound Bites, a lollipop for children which uses the same technology to hear music while biting the candy. The transducers were slightly modified to work with a 30watts amplified signal coming from a regular high-end Altec Lansing PC Speaker system, although low frequency signals were cut for clarity purposes. A 1.5" long titanium rod was attached to the transducers, and a hard plastic surface sized 1"x 1" was then affixed to the tip of the rod. This surface is the contact surface to the mastoid section.



Shown here is the actual transducer. An AA battery is shown for size comparison.

The whole device, except for the plastic surface, was then wrapped with foam, and embedded in a soft cushion-like structure to make the chair comfortable for use.

It is rather important to note that the device had to be free from contact with other surfaces to avoid vibration loss. The structure was designed as to magnify the vibration in the plastic surface, leaving the transducer free to vibrate on the side where the rod was attached.



A model of the headrest structure before installation of the vibration device.

### RESULTS

The prototype was successful and we were able to produce a clear sound with a good volume level for the person sitting in the chair, with no audible signal in the environment. In this way, the person had her hands and ears free, giving her the possibility to maintain a conversation and use a PDA device while listening to music through the bone vibration interface. Later on, a mobile phone was connected to the system instead of the music input, and with a proper microphone a successful result was achieved. The overall cost for the prototype was well below the proposed budget and showed that this kind of interface can be produced at low cost.

### CONCLUSION

Sound interfaces in public spaces sometimes neglect the privacy of "non-users" and contaminate the environment with noise.

In a similar fashion, some private interfaces (such as mobile phones or headphones) can be disturbing in public places, uncomfortable or even dangerous in some situations where attention to the sound environment information is needed (driving, walking, etc.).

A simple solution was presented in this paper, and a cheap prototype was built in order to prove its viability. Bone conduction interfaces seem to be a good solution for the abovementioned situations, and its implementation in both public and private spaces should be a subject of future study.

### ACKNOWLEDGMENTS

We thank Robb Bifano from NYU CAT Lab and Fred Hansen from NYU Physics Dept. for their help in the construction of the prototype. We also want to thank Ric Scofidio for his chair design.

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