# Auditory Feedback for Earpicks

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**Abstract.** We often clean others' ears for the purpose of hygiene and communication. However, this activity has a risk of injuring the ears from applying too much force because it is difficult to grasp the movement and position of an earpick. To solve this problem, we present novel techniques to provide cues for grasping behavior of the earpick using auditory feedback. We implemented two techniques: 1) direct feedback of scratch sound and 2) conversion of force applied to the ear canal to audible signal. We conducted two experiments to study whether these techniques can help users control the exerted force. Contrary to our expectation, the results of the first experiment showed that the direct feedback of scratch sound had no helpful effect on force control. However, the results of the second experiment showed the marginally significant effect that the conversion of force applied to the ear canal to audible signal reduced force. This result indicates that the audification of the force helps users to control the force.

**Keywords:** Auditory feedback, Human interface, Ear cleaning, Earpick.

## 1 Introduction

Ear cleaning is a familiar behavior for many people and it is performed often. The main purpose of ear cleaning is to remove the earwax in the ear canal. However, there are many reasons why we may clean others' ears, such cleaning one's partner's ears or parents cleaning their infants' ears; thus ear cleaning is also a type of communication, if not an entertainment.

However, cleaning the ears of others is generally difficult because the width of the ear canal is very small—6 mm on average in an adult—and its depth is 30 mm on average [6]. Furthermore, while tactile cues from the ear canal play an important role when cleaning one's own ears, this cue is removed when cleaning other people's ears, and the small tactile signal transmitted from the earpick becomes the only cue. These difficulties can result in excessive force and sometimes injury.

As a means for solving this problem, earpicks with visual assistance functionality are commercially available. Some illuminate the internal ear via LEDs, while others use an endoscope. However, two issues remain to be solved: occlusion by the earpick itself, and cost.

adfa, p. 1, 2011.

In this paper, we propose a method to improve the safety of ear cleaning by supplementing auditory cues. We evaluated two methods: the direct feedback of scratch sound, and the conversion of force applied to the ear canal into an audible signal.

## 2 Related work

Attempts to improve the operability of the tool by applying tactile or aural cues have principally been made in the medical field. Yao et al. [7] developed an enhanced probe that can detect small wounds used in arthroscopy. The probe detects a slight acceleration signal that occurs when it traces damage, and magnifies it for tactile and auditory sensation. Also, in the field of telesurgery, detection of the acceleration signal at the slave side is magnified and transmitted to the master side as tactile and auditory feedback [4, 5]. These studies reported that the operability of the tool was improved by the auditory cues.

## 3 Method 1: direct feedback of scratch sound

**System:** We developed an earpick device that detects and amplifies scratch sound [3]. **Fig. 1** shows the system overview. The device is composed of a silicon microphone (Knowles Electronics Inc., SPU0409HD5H), an earpick made of bamboo, an amplifier and an earphone. The scratch sound from the earpick is detected by the microphone, amplified by the amplifier, and presented to the user via the earphone. Users can adjust the amplitude by changing the volume of the amplifier.

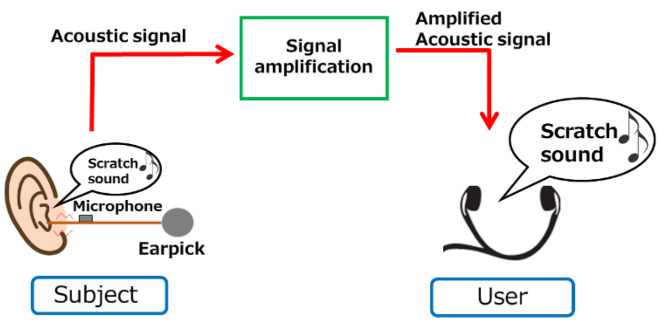


**Fig. 1.** Direct feedback of scratch sound.

### 3.1 Experiment

The purpose of the experiment was to determine whether users can more clearly understand the contact state of the earpick using the scratch sound. We expected that this feedback would facilitate more precise force control, so that the force exerted while cleaning would be changed.

**Experiment environment:** **Fig. 2** shows the experimental system overview. The system comprises the ear model for medical procedures practice (Kyoto Kagaku Co., Ltd., foreign body removal practice unit, 11222-000[M88]) and a six-axis force sensor (NITTA Corp., TFS12-10); both were fixed to a desk with an acrylic plate. We also used pseudo earwax (Kyoto Kagaku Co., Ltd., foreign materials for removal practice) for the experiment. The force sensor was situated 50 mm under the ear model, and detected the torque applied to the ear canal. The signal of the force sensor was recorded by the PC via an AD board (interface Inc., PCI-3523A, voltage range ± 10 V, 12-bit resolution).

**Participants:** We recruited ten participants (seven males, three females, 22–29 years old, all right-handed). None reported any auditory impairments.

**Experimental procedure:** Participants sat in front of the desk, and wore a single earphone in their right ear (**Fig. 2**). They controlled the volume to the extent that they could hear sound clearly but it was not unpleasant. They were asked to treat the pseudo ear like the actual ear, and not to touch the acrylic plate. They were informed that the pseudo earwax was adhered evenly inside the pseudo ear, and they were instructed to clean separate regions one by one, as shown in **Fig. 2**. Ear cleaning was carried out until participants felt that it was cleaned. Participants were asked to take 20 seconds rest after one region was cleaned. The experimenter checked that the pseudo earwax had been removed completely after ear cleaning. Participants carried out the task under two conditions: with and without scratch sound feedback. To avoid order effects, we separated the participants into two groups. One group started in the with-sound-feedback condition (participants A, B, C, D, and E), and the other group started in the without-sound-feedback condition (participants F, G, H, I, and J). We recorded the maximum norm of the torque applied to each area as the evaluation value for each condition. After the experiment, we conducted a questionnaire on the usability of the system.

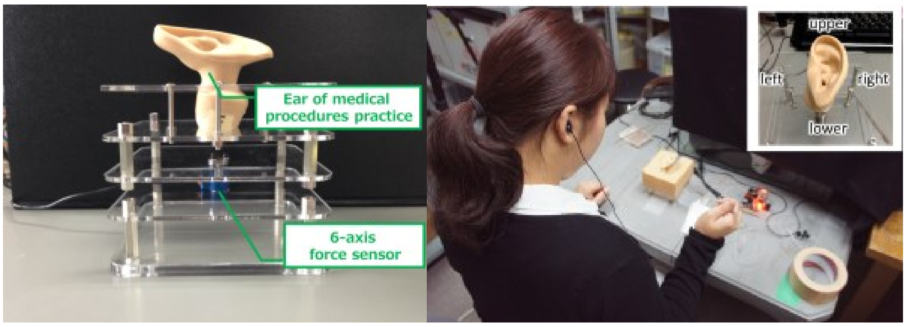


**Fig. 2.** Artificial ear and the 6-axis force sensor for Experiment (left), overview of Experiment (right).

### 3.2 Results

**Fig. 4** left shows the results of this experiment. The horizontal axis shows participants, and the vertical axis shows the average of the maximum norm of the torque applied to each area of the ear canal. Error bars shows standard deviation. A one-way analysis of variance (ANOVA) of the three conditions, feedback order, feedback conditions and areas did not show any significant difference in the mutual effect and main effect.

### 3.3 Discussion

Contrary to our expectations, this result showed that scratch sound feedback does not facilitate more precise force control. This feedback is considered to be effective in understanding the texture and state of touch [6, 7], but it was not found to affect force control.

## 4 Method 2: conversion of force applied to the ear canal to audible signal

Based on the results of the previous section, that scratch sound feedback does not affect force control, we propose a new method that converts force applied to the ear canal into an audible signal. There are several studies that have used audio signals for bio-feedback, such as to improve body balance and motor skills [1, 2]. We hypothesized that by converting force applied to the ear canal to an audible signal, users would clearly be able to grasp the amount of exerted force, and thus would better be able to control it.
**System:** The system setup was similar to the previous experiment, but a 6-axis force sensor was situated 65 mm under the ear model. **Fig. 3** shows the system structure. The force applied to the pseudo ear was obtained from the 6-axis force sensor and sent to the PC via the AD board (Interface Inc., PCI-3523A, voltage range ± 10 V, 12-bit resolution). The norm of the torque was calculated by the PC, multiplied by a 1.5 kHz sine wave and presented to the user via earphone. In this way, users heard a stronger tone when they exerted a stronger force. In future systems, the force will be measured by a force sensor in the earpick, e.g., by piezo-electric film, but here we used an external sensor as an initial trial. In our system, the maximum volume was set to 97 dB (A) when the norm of the torque was 3.0 N cm.

### 4.1 Experiment

**Participants:** We recruited six participants (three males, three females, 22–29 years old, all right-handed). None reported any auditory impairments.
**Experimental procedure:** Participants sat in front of the desk and wore headphones in both ears (**Fig. 3**). They were asked to treat the pseudo ear like the actual ear, and not to touch the acrylic plate. They were informed that the pseudo earwax was adhered to the upper area of the pseudo ear, and they performed ear cleaning. In this experiment we fixed the number of scratches as three times in one trial, and asked the participants to clean as best as possible within this number. When one set was finished, the experimenter checked that the pseudo earwax had been removed completely, and set new pseudo earwax at the same area. Participants carried out the trials under two conditions: with and without audible feedback of the force. We divided the participants into two

groups. One group started in the with-audible-feedback condition (participants A, B, and C), and the other group started in the without-audible-feedback condition (participants D, E, and F). Each condition had five trials, and the participants performed 10 trials in total. The first trial in each condition was regarded as a practice and thus not included in the evaluation. We recorded the maximum norm of the torque applied to each area. After the experiment, we conducted a questionnaire survey on the usability of the system.

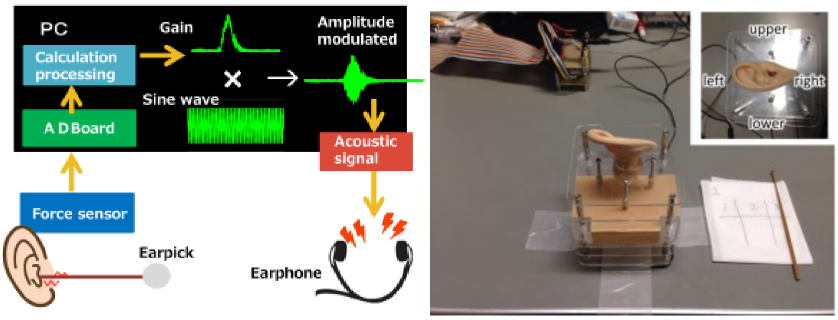


**Fig. 3.** System whereby force applied to the ear canal was converted to an audible signal (left), overview of experiment (right).

### 4.2 Results

In this experiment we fixed the number of scratches as three times in one trial, but we used the results from the second scratch because it was more suitable than the other two. **Fig. 4** right shows the result of the experiment. The horizontal axis shows participants, and the vertical axis shows the average of the maximum norm of the torque applied to the ear canal. Error bars show standard deviation. A one-way analysis of variance (ANOVA) of the two conditions, feedback order and feedback condition, showed a marginally significant difference in feedback condition ($F(1,4) = 4.91$, $p < 0.1$).

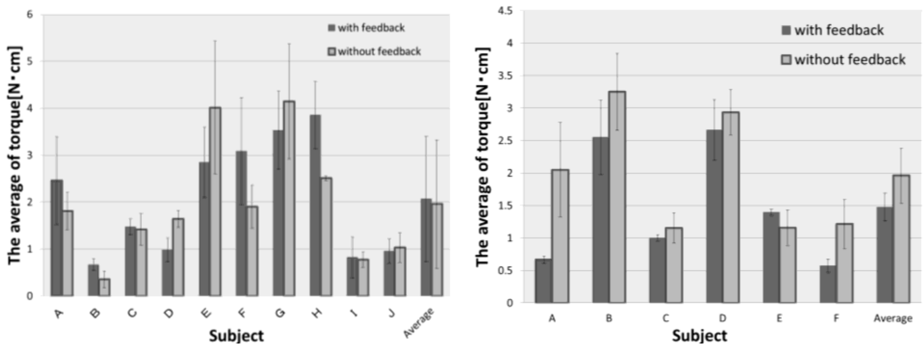


**Fig. 4.** Results of experiment. Method 1(left), Method 2 (right)

### 4.3 Discussion

As we expected, this result showed that an aural signal converted from force reduces exerted force, even though we did not tell participants what they were expected to do. **Fig. 4** shows that the standard deviation of the maximum norm of the torque became small, which suggests that the exerted force was stabilized by this feedback.

## 5 Conclusion

In this paper, we proposed and evaluated two methods to improve the safety of ear cleaning by supplementing auditory cues. The first method was to directly feedback scratch sound from the ear pick when cleaning another's ears. The results indicated that this sound cue did not effectively facilitate the user's force control. The second method was to convert the force applied to the ear canal into an audible signal. The results showed that the force applied to the ear canal was decreased and stabilized.

Although the system was implemented in the experimental environment, we think that it would be quite easy to make the system compact, such as by using a small strain gauge.

## References


1. Chiari, L., Dozza, M., Cappello, A., Horak, F.B., Macellari, V., Giansanti, D.: Audio-Biofeedback for Balance Improvement: An Accelerometry-Based System. IEEE Transactions on Biomedical Engineering, vol. 52, no. 12 (2005)
2. Hasegawa, S., Ishijima, S., Kato, F., Mitake, H., Sato, M.: Realtime sonification of the center of gravity for skiing. AH '12 Proceedings of the 3rd Augmented Human International Conference (2012)
3. Koge, M., Kurihara, Y., Okazaki, R., Hachisu, T., Kajimoto, H.: Safer Ear Cleaning by Adding Auditory Feedback. Entertainment Computing (2013) (In Japanese).
4. McMahan, W., Gewirtz, J., Standish, D., Martin, P., Kunkel, J.A., Lilavois, M., Wedmid, A., Lee, A.I., Kuchenbecker, K.J.: Tool Contact Acceleration Feedback for Telerobotic Surgery. IEEE Transactions on Haptics, vol. 4, no. 3, 210-220 (2011)
5. Okamura, A.M.: Methods for haptic feedback in teleoperated robot-assisted surgery. Industrial Robot: An International Journal, vol. 31, no. 6, 499-508 (2004)
6. Schuenke, M., Schulte, E., Schumacher, U., Ross, L.M., Lamperti, E.D., Voll, M.: THIEME Atlas of Anatomy Image Collection—Head and Neuroanatomy. 140-143 (2007)
7. Yao, H.-Y., Hayward, V., Ellis, R.E.: A Tactile Enhancement Instrument for Minimally Invasive Surgery. Computer Aided Surgery, vol. 10, no. 4, 233-239 (2005)