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# Effects of Listening Attitudes on Affective Evaluation of Switch Sounds

Kenji OZAWA*, Kousuke YAMAJI*, Takeshi SHIRASAKA**, Katsuya SAITO**,

and Hisato SHIMOMURA**

** University of Yamanashi, 4-3-11 Takeda, Kofu-shi, Yamanashi 400-8511, Japan*
*{ozawa, t14cs055}@yamanashi.ac.jp*
*** Alps Alpine Co., Ltd., 1-7 Yukigaya-otsuka, Ota-ku, Tokyo 145-8501, Japan*
*{takeshi.shirasaka, katsuya.saito, hisato.shimomura}@alpsalpine.com*

**Abstract:** Switch sounds are not always pleasant for *passive listeners* although they are comfortable for *operators* to confirm the completion of their operations. An example is how the sounds of keyboard typing of other passengers are deemed noisy in a railway train. This difference in affective evaluation may be due to the attitudes of listeners: the operator is in an active listening attitude with tactile feedback from the pushed switch whereas a usual listener is in passive listening attitude. To separate the effects of tactile information and listening attitudes, we defined an *active listener* as one in an active listening attitude but without tactile feedback. To examine these effects on affective evaluation of switch sounds, a psychoacoustical experiment was carried out using 15 switches. The sound quality of each switch sound was evaluated by the semantic differential (SD) method using 26 adjective pairs. Eighty-one subjects participated in the experiment as one of the roles of *operator*, *active listener*, and *passive listener*. The results were analyzed using factor analysis; the three factors of *activity (brightness)*, *evaluation (aesthetic state)*, and *potency (volume)* were extracted. The comparisons of these factor scores among the three roles revealed the following two points. First, the effects of tactile information seem different depending on the switches used. Second, a passive listening attitude results in the negative evaluation of sound: *less active*, *more uncomfortable*, and *noisier.* This finding supports the abovementioned scenario in a train.
**Keywords:** *Switch sound, Sound quality, Listening attitude, Semantic differential method, Factor analysis*

## 1. INTRODUCTION

This study focuses on the sounds or clicks emitted from switches or buttons when they are pushed. From the viewpoint of the manufacturers of switches, the design of such sounds is important for differentiating their products from their competitors' [1-3]. From the consumers' point of view, switch sounds are a matter of interest because mechanical switches as well as electrical buttons are ubiquitous in our daily lives. Indeed, many videos, in which different switch sounds are compared, can be found on social network services (SNS), e.g., YouTube [4] with the keywords "switch sound," indicating people's obsession with these sounds.

Switch sounds are effective for an operator to confirm the completion of an operation. For listeners of the sounds, however, such sounds are not always pleasant. For example, such notices as "Please be considerate of other passengers when using your computer (keyboard noise, etc.)" can be seen on the back of the front seat in railway trains. This practice suggests that the affective evaluations of these sounds are different depending on the attitudes of listeners, namely, *active* or *passive listening*.

A study on the sound quality of 11 buttons using 27 adjective pairs derived the three factors of *metallic*, *esthetic*, and *force* using factor analysis [5]. As the sounds were recorded in advance and presented to 67 participants via headphones, the participants had no tactile feedback of pressing buttons. Therefore, the sounds were evaluated by active listeners. In other words, no evaluations have been conducted by operators and passive listeners.

This study aimed to clarify the effects of listening attitude on the affective evaluation of switch sounds. A psychoacoustical experiment was carried out to evaluate the sound quality of switch sounds from three perspectives, namely, operator, active listener, and passive listener.

## 2. EXPERIMENTAL METHOD

### 2.1 Three roles and participants

To achieve the abovementioned aim, we defined the three roles as follows:

- Operator: A person who pushes a switch and listens to its sound actively.
- Active listener: A person who listens to the switch sound actively by sitting in front of the operator.

- Passive listener: A person who listens to the switch sound passively during a task by sitting next to the active listener.

Passive listeners were asked to focus on playing a simple video game (a kind of ping-pong game) on a note PC screen when the switch sounds were presented.

This study focused on differences in affective evaluation between the *operator* and the *passive listener*. These two roles are different with respect to the following two points: tactile information and listening attitude. To separate these two factors, we introduced the role of *active listener* who cannot receive the tactile feedback but whose attitude must be the same as that of the operator.

Eighty-one participants in their 10s to 50s were recruited for the experiment, which was conducted using a between-subjects design. Each subject was assigned to one of the three roles, and 27 subject groups were formed.

### 2.2 Experimental materials and procedure

Fifteen switches were mounted on a circular board, covered with uniform caps to prevent visual information effects, as shown in Figure 1. Before pushing a switch designated by an experimenter, the operator rotated the board so that the designated switch was located at the nearest position.

The switch sounds were evaluated by the semantic differential (SD) method [6]: the participants rated their impressions of each sound using five-point category scales for the 26 pairs of adjectives shown in Table 1; the asterisks indicate usage in a previous study [5].

In the experiment, an experimenter designated one of the switches in random order. The designated switch was evaluated in two sessions. In each session, the operator continuously pushed the switch for 5 s (approx. 15 times), and the three participants rated the sound using 13 pairs of adjectives arranged in random order.

## 3. RESULTS AND ANALYSIS

### 3.1 Significance of the effect of listening attitudes

First, we examined the statistical significance of the difference in the roles on affective evaluation. One-way analysis of variance (ANOVA) was conducted for each combination of a switch and an adjective pair separately. If the effect of the roles was statistically significant (5% level), multiple comparison with the least significance difference (LSD) method was carried out.

The numbers of switches that show significant difference among the three roles are shown in Table 1. Significant effects were observed for most of the adjective pairs, but the number of significant switches was restricted.

The difference between the operator and the active listener may be due to the tactile information: the operator listened to the sound with the tactile feedback. Thus, the effects of tactile feedback need to be examined in future research.

**Figure 1:** Fifteen switches with uniform caps mounted on a circular board.

**Table 1:** Adjective pairs used in the experiment and the number of switches for which significant differences were observed among the three roles (O: operator, A: active listener, P: passive listener). Asterisks show that the pairs have been used in a previous study [5].

| | Adjective pairs | | | O \| A | A \| P | O \| P |
|---|---|---|---|---|---|---|
| * | High | — | Low | 1 | 3 | 2 |
| * | Loud | — | Quiet | 0 | 0 | 0 |
| * | Likable | — | Dislikable | 3 | 2 | 3 |
| | Calm | — | Noisy | 2 | 1 | 3 |
| * | Heavy | — | Light | 2 | 4 | 6 |
| * | Superior | — | Crummy | 3 | 2 | 4 |
| * | Beautiful | — | Dirty | 1 | 5 | 3 |
| * | Hard | — | Soft | 2 | 2 | 2 |
| * | Boring | — | Pleasant | 1 | 3 | 1 |
| | Bothering | — | Casual | 3 | 0 | 3 |
| * | Sensitive | — | Bold | 2 | 3 | 3 |
| * | Rough | — | Smooth | 2 | 4 | 2 |
| * | Dark | — | Bright | 3 | 5 | 3 |
| * | Strong | — | Weak | 1 | 1 | 2 |
| * | Clarified | — | Blurred | 2 | 4 | 5 |
| * | Long | — | Short | 2 | 5 | 5 |
| | Reverberant | — | Boxy | 5 | 7 | 7 |
| * | Comfortable | — | Uncomfortable | 2 | 2 | 2 |
| | Sharp | — | Dull | 2 | 5 | 4 |
| | Massive | — | Trifling | 3 | 0 | 6 |
| * | Natural | — | Artificial | 0 | 1 | 1 |
| * | Dry | — | Charming | 2 | 3 | 2 |
| * | Uneasy | — | Easy | 1 | 2 | 0 |
| | Hazy | — | Clear | 4 | 6 | 5 |
| * | Flaring | — | Restrained | 3 | 4 | 3 |
| * | Powerful | — | Powerless | 2 | 5 | 3 |

For the difference between the active and passive listeners, the cause of the difference may be the difference in listening attitudes: the active listener paid more attention to the sound evaluation than the passive listener. For the pair "hazy–clear," for example, the passive listener evaluated the sound as *hazier* compared with the active listener. Thus, a passive listener may tend to perceive switch sounds negatively, which is in line with the common experience in a train where the keyboard sounds of another person are deemed noisy. To examine this tendency further, we conducted factor analysis of the results.

### 3.2 Factor analysis

The evaluation scores of all participants and switches for the 26 adjective pairs were analyzed using factor analysis (principal factor solution, varimax rotation); 1,215 observations (27 participants × 3 roles × 15 switches) were analyzed to observe statistical significance that can be attributed to the listening attitudes.

Based on the criterion that eigenvalues must be greater than one, we extracted three factors. Table 2 shows the factor loadings for every adjective pair, contribution ratios, and cumulative contribution ratios in terms of the three factors. The cumulative contribution ratio up to the third factor was 53.2%.

In Table 2, all pairs are sorted by the largest factor loading in the absolute value, which is underlined. All items except for "long–short" loaded at least 0.4 on one or more factors. The first factor, F1, represented *activity* [6] or *brightness* [7] because pairs such as "reverberant–boxy" and "dark–bright" had larger loadings on this factor. The second factor, F2, indicated *evaluation* [6] or *aesthetic state* [7] because pairs such as "comfortable–uncomfortable" and "likable–dislikable" had larger loadings on this factor. The third factor, F3, was regarded as *potency* [6] or *volume* [7] because pairs such as "strong–weak" and "calm–noisy" had larger loadings.

The average factor scores for all participants in each role are shown in Figure 2 for each switch. In the figure, the initial and terminal points of a hollow arrow represent the factor scores of the *operator* and *active listener*, respectively. The initial and terminal points of a solid arrow exhibit the factor scores of the *active* and *passive listeners*, respectively. The changes in factor scores are summarized in Table 3, where the upward (hollow) and downward (solid) triangles imply that the change is in incremental and decremental directions, respectively. Here, changes less than 0.1 in the absolute value were regarded as no change. The changes were analyzed by one-way ANOVA and LSD test. Significant changes are shown in Table 3, indicated by asterisks.

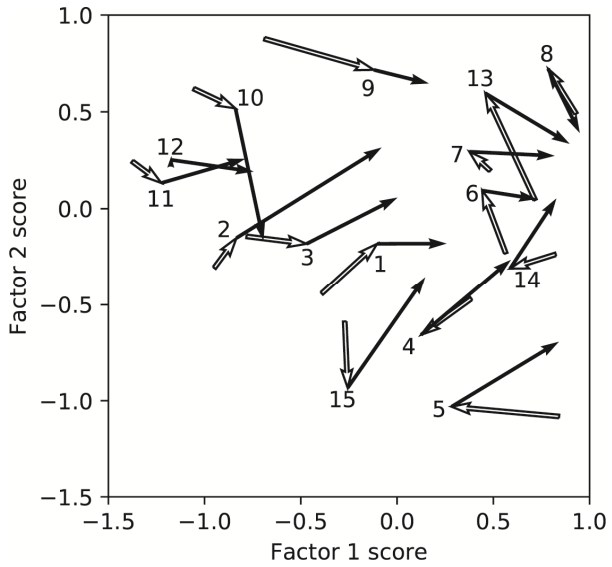
**Table 2:** Factor loadings for 26 adjective pairs after varimax rotation. The largest factor loading in the absolute value for each pair is underlined.

| Adjective pairs | F1 | F2 | F3 |
|---|---|---|---|
| Reverberant — Boxy | 0.76 | -0.01 | 0.29 |
| Sharp — Dull | 0.74 | -0.03 | 0.24 |
| Clarified — Blurred | 0.70 | 0.10 | 0.41 |
| High — Low | 0.70 | -0.12 | 0.33 |
| Flaring — Restrained | 0.68 | 0.01 | 0.46 |
| Dry — Charming | 0.44 | -0.32 | 0.17 |
| Massive — Trifling | -0.56 | 0.34 | 0.39 |
| Heavy — Light | -0.57 | 0.18 | 0.44 |
| Hazy — Clear | -0.70 | -0.25 | -0.11 |
| Dark — Bright | -0.73 | -0.05 | -0.22 |
| Likable — Dislikable | 0.10 | 0.79 | 0.01 |
| Comfortable — Uncomfortable | -0.10 | 0.79 | -0.13 |
| Superior — Crummy | -0.25 | 0.72 | 0.05 |
| Beautiful — Dirty | 0.30 | 0.70 | -0.05 |
| Natural — Artificial | -0.36 | 0.45 | -0.18 |
| Rough — Smooth | -0.42 | -0.44 | 0.24 |
| Boring — Pleasant | -0.31 | -0.51 | -0.26 |
| Uneasy — Easy | 0.02 | -0.68 | 0.01 |
| Strong — Weak | 0.14 | 0.04 | 0.82 |
| Loud — Quiet | 0.19 | -0.13 | 0.77 |
| Powerful — Powerless | 0.19 | 0.21 | 0.69 |
| Hard — Soft | 0.20 | -0.02 | 0.48 |
| Bothering — Casual | 0.31 | -0.42 | 0.46 |
| Long — Short | -0.34 | -0.07 | 0.18 |
| Sensitive — Bold | 0.19 | 0.31 | -0.52 |
| Calm — Noisy | -0.37 | 0.37 | -0.63 |
| Contribution ratio (%) | 21.2 | 16.2 | 15.9 |
| Cumulative contribution ratio (%) | 21.2 | 37.4 | 53.2 |

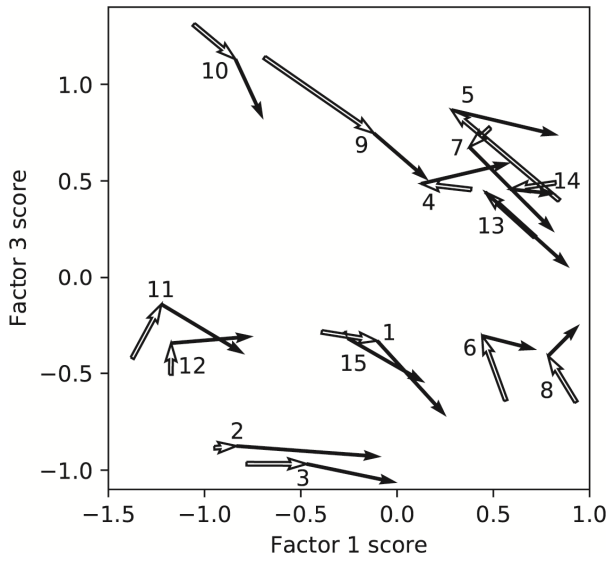
For the changes from the *operator* to *active listener*, systematic tendencies were minimal. The directions seemed to depend on the tactile information of different switches.

Meanwhile, the changes from the *active* to *passive listeners* were notable: the change in F1 scores was incremental for all switches. As larger values were assigned to the raw scores for the rightward adjectives in a pair, shown in Tables 1 and 2, the increase (upward change) in factor scores indicated that switch sounds were perceived as *less active*. For the changes in F2 and F3 scores, the upward and downward changes were predominant, respectively. Thus, passive listeners perceived them as *more uncomfortable* and *noisier*. We can conclude that the passive listening attitude resulted in negative evaluation.

The changes in factor scores from *operator* to *passive listener* showed similar tendencies to those found for the changes from *active* to *passive listeners*. This finding




(a) Factor scores of F1 and F2




(b) Factor scores of F1 and F3

**Figure 2:** Three factor scores for each switch exhibited on the F1–F2 and F1–F3 score planes. The initial points of hollow and solid arrows are the scores for the *operator* and the *active listener*, respectively. The terminal point of a solid arrow indicates the scores of the *passive listener*.

supported the abovementioned scenario of keyboard sounds in a train.

## 4. CONCLUSION

This study focused on the effects of listening attitude on the affective evaluation of switch sounds. The experimental results showed that passive listening attitude results in negative evaluation. Further studies on the mechanical and acoustical properties of switches will be required to examine the experimental results in depth.

**Table 3:** Changes in factor scores among the three roles of operator (O), active listener (A), and passive listener (P). Upward and downward triangles show increase and decrease in factor scores, respectively (* $p$ <0.05).

| Sw. No. | O → A | | | A → P | | | O → P | | |
|---|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F3 | F1 | F2 | F3 | F1 | F2 | F3 |
| 1 | △ | △ | | △ | | ▼* | △* | △ | ▼* |
| 2 | △ | △ | | △* | △* | | △* | △* | |
| 3 | △ | | | △* | △ | | △* | △ | |
| 4 | ▼ | ▼ | | △ | △ | △ | △ | △ | △ |
| 5 | ▼* | | △* | △* | △ | ▼ | | △ | △ |
| 6 | ▼ | △ | △ | △ | | | △ | △ | △ |
| 7 | ▼ | | | △* | | ▼ | △* | | ▼* |
| 8 | ▼ | △ | △ | △ | ▼ | △ | | | △ |
| 9 | △* | ▼ | ▼ | △ | | ▼* | △* | ▼ | ▼* |
| 10 | △ | ▼ | ▼ | △ | ▼* | ▼ | △ | ▼* | ▼* |
| 11 | △ | ▼ | △ | △* | △ | ▼ | △* | | |
| 12 | | | △ | △* | | | △* | | △ |
| 13 | ▼ | △* | △ | △* | ▼ | ▼ | △ | △ | ▼ |
| 14 | ▼ | | | △ | △ | | | △ | |
| 15 | | ▼ | | △* | △* | ▼ | △* | △ | ▼ |
| # of △ | 6 | 5 | 6 | 15 | 7 | 2 | 12 | 9 | 5 |
| # of ▼ | 7 | 5 | 2 | 0 | 3 | 8 | 0 | 2 | 6 |

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