Basic Research on Multisensory Methods for Teaching Onomatopoeia to the Hearing-impaired

Broadening the Experience of Sound

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Abstract: It is difficult for hearing-impaired individuals to learn animal sounds and the onomatopoeia that depict them because they have limited or no access to auditory information. To attempt to solve this problem, the author designed a science lesson to help hearing-impaired students learn cicada songs. This lesson used multiple media including text, images, sounds, sound waveforms, onomatopoeia and vibrations to stimulate the senses of sight, hearing and touch. An experiment was conducted on 26 hearing-impaired students, who were split into two groups. One of the groups was provided with vibrations as part of the lesson and the other was not. Pre- and post-tests on the names of cicadas and their songs and a lesson evaluation survey were conducted to assess the lesson's effectiveness. Although results showed no significant difference in learning between the two groups, students who were able to discriminate among the different vibrations reported that they found the lesson enjoyable and that it was a useful way to learn science.

1 INTRODUCTION

The Japanese language is said to use from three to five times as many onomatopoeic words as western languages or Chinese (Yamaguchi, 2003). The one dictionary of Japanese mimetics lists 4500 entries (Ono, 2007). Educational research has suggested that onomatopoeia, that is, words which mimic animate sounds (giseigo), inanimate sounds (giongo) or are symbolic of states (gitaigo), of emotions (gijougo) or of actions (giyougo), are easy for students to understand and enhance their comprehension and imagination (Miyazaki and Tomimatsu, 2009), that high iconicity between the sound and the referent enables listeners to accurately generalize the meaning of the word and to make an immediate connection with the object being symbolized, and, that sound symbolic words referring to states, emotions or actions facilitate the learning of verbs as children are acquiring vocabulary(Imai and Kita, 2014). So learners of the Japanese language must master onomatopoeia to make their Japanese more descriptive and expressive(Yusuf and Watanabe, 2008).

In this way, onomatopoeia plays an important role in word acquisition, child development and education. It has also been found that, when using the auditory modality in the education of hearing-impaired children, onomatopoeia teaches vocalization patterns and how to associate meaning with words, which facilitates verbalization (Nakamura, 2007). This suggests that onomatopoeic words are important for the hearing-impaired to learn. Other studies have found that when deaf individuals understood spoken sentences, not only the brain's left hemisphere (as in native speakers with normal hearing) but also the right brain was extensively activated (Neville, 1998), and that deaf individuals used phonological representations in visually presented verbal memory tasks similar to people with normal hearing (Okada and Matsuda, 2015). However, when deaf subjects were asked to judge the appropriateness of the use of sound symbolic words depicting states, actions or emotions to describe scenes in a video, the visual and auditory association areas in the brain were not activated (Arata and Matsuda, 2009). These findings support the idea that it is difficult for hearing-impaired individuals, who have difficulty accessing auditory information, to construct linguistic symbols using the sound symbolism of onomatopoeic words, in spite of their synesthetic and sound-symbolic characteris-

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tics (Hinton and Ohala, 2006). Thus, onomatopoeias (also referred to as sound-symbolic words) are difficult for these individuals to learn. However, thinking in another way, even without the ability to hold sound symbols in memory in the absence of auditory information, one can postulate that they may be able to construct other linguistic symbols if a multisensory environment is created to provide alternative sensory information, such as vibrations or visual information. In particular, hearing impairment has been linked to a heightened sense of touch (Heidenreich and Lewin, 2012). Previous research on information accessibility and sensory substitution for the disabled has shown that haptic information is effective in speech training (Alves and Freire, 2015). Practical applications using vibrations to provide alerts are already available, such as, vibrating alarm clocks, vibrating devices worn in the hair (Honda, 2016), and applications that alert the user to sounds indicating danger (Henriquez and Travieso, 2013). In addition, information provided through vibrations enables hearing-impaired individuals to recognize rhythms and enjoy music (Kanebako and Namatame, 2016). This makes the use of vibration promising as an alternative to auditory information. Consequently, the author attempted to develop lesson which would enable people with impaired hearing to learn sound symbols. A multisensory lesson was designed to teach onomatopoeias mimicking animal sounds, which broadened learner experience beyond sound by simultaneously presenting them with haptic and visual information in addition to auditory information.

2 PURPOSE

The purpose of this study was to find out what component elements hearing-impaired learners appreciate in a multisensory lesson designed to teach onomatopoeias for animal sounds by broadening the learner experience of sound and whether vibration as a form of haptic information can play a complementary role to auditory information in learning.

3 EXPERIMENTAL METHOD

In this report, we develop the teaching materials promoting understanding for synesthesia about the kind of the experience like insect (cicada) sound which the hearing-impaired was not able to learn because acquisition of the hearing information is difficult.

We measure the learning effect by comparing the cases when the vibration information is added or not added. The evaluation of the way of receiving and the teaching materials for the sense of touch (vibration) will be obtained.

3.1 Design of Teaching Material

Because the body of the cicada is the housing, the best way to learn the cicada's song is the touching of a cicada. However, it is difficult to hear the original sound because the cicada makes a different sound when the cicada is touched. Therefore we designed the multimedia teaching materials which appealed to hearing, the sense of touch, sight to help the learning of the sound of cicada.

We chose seven kinds of cicadas which are well-known in Japan. The teaching materials contents are constituted by the commentary sentence about the habits of the cicada, the onomatopoeia of the cicada's song, the images of cicada, the sound information of the cicada's song, the waveform of the cicada's song, vibration. In the main display, the commentary sentence of the cicada and onomatopoeia and an image and the button of the cicada's song are shown.

Figure 1: Configuration of the learning materials.

Table 1: Specifications of the cicadas' sound.

cicada	onomatopoeia	time ms	volume db	vibration m/s2
1	Jiri-jiri	45	95	2.8
2	Achi-achi	40	95	27.0
3	Kana-kana	46	93	9.2
4	chi. chi. chi.	41	91	3.7
5	Tsuku-tusku	42	95	3.3
6	min-min	46	95	3.0
7	Chiiii...	45	100	0.6

The sound waveform of the cicada's song emerges to a vice-display when a button is clicked, and the cicada's song is played back. The vibration links with the cicada's song by using a vibration speaker. The cicada's song is edited so that it becomes 93db(+-2db) for approximately 40 seconds. In addition, the presentation of the cicada in the learning using the teaching materials is shown at random every time.

The presentation of the cicada is shown automatically when the learner clicks the start button. The learner can read the commentary sentence of the cicada and onomatopoeia, and then click the button of the cicada's song. The learner get the cicada's song and the sound waveform with the vibration.

The constitution of the learning materials is shown in figure.1, the sound condition of each cicada is shown in table.1.

3.2 Experiment Procedure

The experiment was conducted from 27th Jun. until 6th Jul. in 2017. We had 26 participants with hearing-impaired (Average age: 21.1 years old). The participants were divided into two groups. Group A was 17 participants using the vibration device, and Group B was 9 participants not using the vibration device. The experiment was 30 minutes in total per person. Experiment procedure is following.

1: Informed consent and experiment explanation
2: 2back task (working memory task)
3: PreTest
4: Learning
5: Post Test
6: Questionnaire evaluation

3.3 Evaluation Method of the Lesson

This lesson used multiple media including text, images, sounds, sound waveforms, onomatopoeia and vibrations to stimulate the senses of sight, hearing and touch. The following 8 questions were prepared to evaluate the lesson.

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Q1: Good material
text, images, sounds, sound waveforms,
  onomatopoeia, (vibrations)
Q2: Did you hear anything?
Q3: Did you distinguish those vibrations?
Q3':(or Did you need vibration?)
Q4: The degree of easy intelligibility
Q5: The degree of useful
Q6: The degree of interesting
Q7: The degree of enjoyable
Q8: The degree of educative
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4 RESULT

4.1 Learning Ability of Participants

As a baseline information, participants were assigned the 2 Back-task, which you need to decide if the current number is the same as the one presented 2 trials ago, in order to assess the working-memory. After a practice, formal experiment was conducted twice. As the mean score of a percentage of two answers were calculated, mean score of experimental group was 53.2% and that of control group was 57.9%. In order to assess the knowledge of cicada's song, the participants connected the 7 cicada's names and 7 cicada's song (Onomatopoeia) as one by one, before and after the learning. As a result, a percentage of correct answers of pre-test was 3.9 for experimental group and 3.8 for control group. That of post-test was 6.8 for experimental group and 6.6 for control group. That is, almost all the participants became able to match the cicada's name and song (Onomatopoeia) after the learning. Therefore, we regarded the working-memory and leaning effect of the participants as equal, and compared the subjective evaluation about the lesson between the experimental group and control group.

4.2 Evaluation About the Lesson

These figures (Figure 2Figure 3) show the percentage that evaluation about good points of the lesson. The vertical axis shows a percentage and horizontal axis shows the alternatives. The alternatives are caption, photo, onomatopoeia, sound, waveform and vibration. This question was multiple answers. The each population were the 17 participants which gave vibration information, and the 9 participants which didn't give vibration information.

With or without vibration, we can read that the onomatopoeia were evaluated as a factor to constitute lesson. When there was not vibration, the sound was estimated as an onomatopoeia at the same level, but

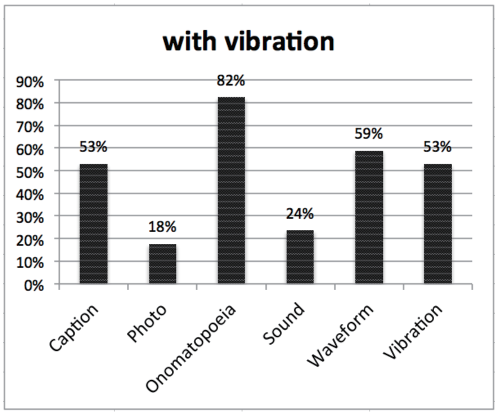

Figure 2: Good element (Vib.).

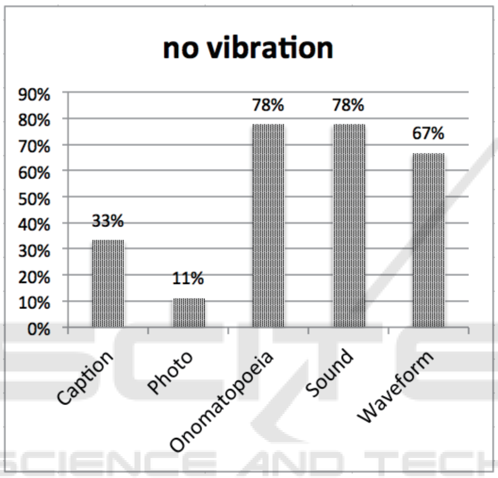

Figure 3: Good element (no Vib.).

the sound was not evaluated too much when there was vibration.

4.3 Subjective Evaluation About the Lesson

The likert-scale was marked every one point and was calculated for getting the average. The point of scale was following.

```
+2point: strong-agree
+1point: agree
 0point: not either
-1point: disagree
-2point: strong-disagree
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The result shows the figure.4.

In order to check the differences between group A (with vibration) and group B (without vibration), T-test was analyzed. But there were not significant differences.

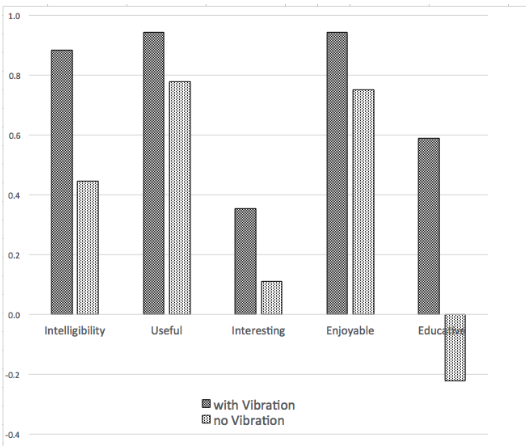

Figure 4: Comparison of the subjective evaluation.

4.4 Relation of the Sense

We made two questions about the sense of hearing and touching. Q2Did you hear anything?, Q3Did you distinguish those vibrations? The t-test was examined to provide significant difference of their feeling and subjective evaluation. The population was the 17 participants which gave vibration information. They were separated into positive group and the negative group. The positive-group was comprised of ”agree” ”strong-agree”, and the negative-group was comprised of ”disagree”,”strong-disagree” and ”not either”.

4.4.1 Q2Did You Hear Anything?

The result that The 11 participants was ”can hear something” and the 6 participants was ”can’t hear anything”. There was no significant difference between the subjective evaluation (IntelligibilityUseful, InterestingEnjoyableEducative) and hearing-feeling. The result shows that it was not different in the evaluation of the lesson by the degree of the hearing.

4.4.2 Q3Did You Distinguish those Vibrations?

The result that The 11 participants was ”can distinguish” and the 6 participants was ”can’t distinguish”. There were significant differences between the subjective evaluation about ”Interesting”$t(15)=3.05$, p.05)and ”Educative”$t(15)=2.49$, p.05).

The table.2 shows that an evaluation is higher in the person who was able to distinguish the vibration.

Table 2: Distinction of the vibration and evaluation of the lesson.

	distinguish AverageS.D.	no distinguish AverageS.D.
Intelligibility	1.09(0.70)	0.50(0.84)
Useful	1.27(0.47)	0.33(1.21)
Interesting	0.45(0.82)	0.17(0.75)
Enjoyable	1.27(0.65)	0.33(0.52)
Educative	1.00(0.77)	-0.17(1.17)

5 DISCUSSION

The purpose of this study was to find out whether a multisensory lesson to teach sound symbolic onomatopoeias for animal sounds by broadening the learner experience of sound beyond auditory information could facilitate learner comprehension. The subject of the lesson was cicada songs. Analyses were based on participants' evaluations of the lesson and on tests to determine if the lesson had an effect on participants' learning .

Results showed no significant difference in learning between two groups of participants (26 in total), one that was provided with vibrations as part of the lesson and one that was not. Post-lesson test results showed improvement over the pre-lesson results with almost all participants ultimately answering all the questions correctly. However, to properly assess the lesson's effectiveness, knowledge retention needed to be measured by conducting another test at some set period of time after the lesson.

There were inconsistencies in how participants were able to feel the vibrations in the lesson, which suggested that the vibrations were not provided in a way that everyone could understand them. Lesson content consisted of an explanation of cicada ecology, the onomatopoeia for the cicada's song, a picture of the cicada, the cicada's song (auditory information), its sound waveform and, for one of the groups, a vibration.

Regardless of whether vibrations were included in their group, most participants rated the onomatopoeias for the songs as a good element in the lesson. They thought they were useful for learning sound symbolic words as they conveyed the sounds in word form.

For the group in which vibrations were included as an element in the lesson, fewer of the participants selected the songs auditory information than the vibration as a good element in the lesson, suggesting that they may have tried to make more use of vibrations when they were available. On the other hand, when vibrations were not included, more of those participants appreciated the inclusion of the songs auditory information. This indicated that these hearing-impaired individuals were using their residual hearing.

No statistically significant difference was found in the subjective evaluations of the lesson between the groups given and not given the vibrations. Nor was there any significant difference in evaluation results due to the degree to which participants reported they were able to hear sounds.

However, a significant difference was shown due to differences in how participants were able to feel the vibrations. Those that were able to discriminate among them reported they found the lesson fun and that it could be used for teaching science. Given that including vibrations in a lesson may make learning sound symbolic words enjoyable, it may be promising to put them to use in science lessons for young children with poor hearing.

6 CONCLUSION AND FUTURE TOPICS

The elements of the multisensory lesson on onomatopoeia that broadened learner experience of sound and were most appreciated by the participants in this study were the onomatopoeia, the sound waveforms for the cicada songs, and either the song or its vibration, depending on which group they were assigned to.

The study demonstrated that haptic information like vibrations is a useful alternative to sound that complements auditory information for people with difficulty hearing. While results did not show that the inclusion of vibrations in the lesson facilitated learner comprehension of sound symbolic onomatopoeia, it did show vibration to be a promising element for inclusion in educational materials for the hearing impaired.

In the future, it may be possible to develop more effective lessons by using better vibration devices that can vibrate in more distinctive ways. Better devices are needed that can convey more nuances and higher registers of sound, not vibrate the way an alarm does.

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