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Master's Thesis
Academic Year 2019

Suggesting a New Way of Learning English: A Study on Effectiveness of Applying Haptic Stimulations to Enhance Ability of English Listening

Keio University
Graduate School of Media Design

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A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

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Abstract of Master's Thesis of Academic Year 2019

Suggesting a New Way of Learning English: A Study on Effectiveness of Applying Haptic Stimulations to Enhance Ability of English Listening

Category: Design

Summary

This study aimed to suggest applying haptic stimulations for a new way of English learning and to confirm whether it is effective or not. The current ways of English learning are not focusing on conversations which many of the Japanese are not good at. In addition to this, the Japanese have a strong tendency of not being able to listen to English words correctly due to a negative transference of the structure of Japanese. Therefore, a new way of English learning must be suggested. In this study, taking mechanisms and characteristics of language learning and human senses into account, vibrotactile devices were designed and developed. These devices were intended to emphasize English phonetic elements which are obscure to the Japanese. With these devices, 3 experiments were conducted: about effectiveness for detecting vowels in an English word, about effectiveness for detecting the stress in an English word, and for confirming its effectiveness strictly. The 1st was conducted to confirm whether it enhances a listening skill of detecting vowels in an English word because the Japanese are bad at it. The results implied that the device was not helpful for vowels detection by listening because its mechanical and simple emphasis annoyed learners. This experiment showed that inappropriate stimulations rather destruct participants. The 2nd was conducted to confirm whether a new device enhances a listening skill of detecting a stress in an English word. This experiment had 3 versions depending on its paradigm to clarify for what the device is effective. The results implied that haptic stimulations helped participants with detecting the stress of newly learned words. The

3rd was conducted to confirm whether the results observed in the 2nd experiment was robust or not. The results implied that the hypothesis was not fully right, but partially right. According to its results, the haptic stimulations impressed the stress position of an English word and affected participants memory and their ways of thinking. Through these experiments, it was implied that haptic stimulations have a strong effect to impress vague elements in pronunciation, and may be applied to education or the media, but further researches are required because of strong limitations of this experimental setup.

Keywords:

Haptic, Tactile, Multisensory, English, Learning, Education

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Chapter 1
Introduction

1.1. The Demand of English in Japanese Society

Recently, the demand of English has increased in Japan.

According to the report of JNTO, Japan National Tourism Organization, tourists visiting Japan has been increasing [1]. The Japanese Ministry of Justice also estimates that not only tourists, but also immigrants will increase and it recently revised Immigration Control and Refugee Recognition Act so that more foreigners can come, work and live [2].

Additionally, the MEXT, Ministry of Education, Culture, Science, Sports and Technology, also revised the Course of Study in Japan to practice English education in elementary schools [3].

Finally, according to a report by the Cabinet Office on learning and lifelong education, learning Languages such as English is the learning activity which adults would like to make the most if there is an opportunity [4].

To sum up, it is strongly suggested that the demand of English has been increasing.

1.2. Problems in Japanese English

However, the English scores of Japanese people are not so high, rather low, according to some reports by ETS, the responsible organization for TOEIC and TOEFL [5], [6]. Especially, many Japanese are not good at speaking and conversations [6]. A English teaching company lists 10 patterns of Japanese common English pronunciation errors [7].

According to this table, it may be suggested that the Japanese are bad at vowels because 5 in the table are related to vowels(No.2, No.4, No.6, No.8, and No.10).

Table 1.1 According to Pronunciationstudio, a company teaching English intonation and pronunciation, the Japanese tend to make the following errors.

	Error Pattern	Brief Description
No.1	l or r	confuse "l" and "r"
No.2	Schwa	cannot pronounce the neutral weak vowel of schwa
No.3	'th' Fricatives	confuse "th" with "t", "s", "z", or "d"
No.4	12 vowel positions	cannot pronounce the English vowels as they are
No.5	Word Stress	pronounce all the vowels equally
No.6	Added Syllable	joining a syllable after consonants
No.7	Sentence Stress	pronounce all the syllables equally
No.8	Diphthong vowel	cannot pronounce the neutral vowel
No.9	Joining	separating words when speaking and sounds immature
No.10	Consonant Clusters	place a vowel between consonant clusters

This may be due to a difference between the way of vowels are spoken in Japanese and that of English. As known empirically, Japanese words usually end with vowels, because basic Japanese words consist of open syllables which ends with a vowel, so usual Japanese words have many vowels in them, but English words frequently consist of close syllables which end in a consonant and English words usually have less vowels than Japanese ones [8]. Therefore, a native Japanese speaker may not be able to adapt to this difference in a conversation.

However, it is also suggested that this difference affects a Japanese speaker not only in speaking, but also in listening.

According to Dupoux et al(1999), the Japanese cannot listen to a cluster accurately, which is a set of continuous consonants often seen in European languages. The Japanese add vowels between the elements of a cluster. Their study found that Japanese cannot discriminate the pronunciation of [ebzo] from [ebuzo] and implied the Japanese tend to hear foreign words similarly to Japanese. Additionally, another study implied that this habit of adding vowels is unconscious and strong [9].

This may matter not only conversations, but also general language acquisition. There is a theory that language is acquired by imitating an inner language model formed by being exposed to it [8]. If so, wrong hearing means exposure to an incorrect language, and it will lead to forming a wrong model. Thus, the language acquisition based on a wrong model cannot help but result in failure.

Therefore, this habit of incorrect listening should be fixed.

1.3. Current Style of English Education

Taking these arguments into account, listening can be an essential and critical point, but, probably, present education styles are not focusing on it.

According to Teshima(2011), many of Japanese schools do not pay much attention to phonetics and an English class is often held in *katakana* English, which probably accelerates the bad habit. However, accurate and precise lectures on phonetics must be boring and hard to understand [10], which will deaden learners' interest.

Then, a new way of language learning for listening is needed.

1.4. Purpose

This study aims to find a new effective way for English listening.

The big problem lying in current educational style may be a lack for an opportunity of effective listening education. This needs to be changed to a new attractive and effective style that enables learners to understand correct listening, not only for conversations, but also for general language acquisition.

Therefore, the purpose of this study is to suggest a new way enabling learners to understand correct listening clearly, and check whether it is effective or not.

To accomplish this, taking a stream of a recent research flow and the character of human senses into account, haptic stimulations were applied. Thus, the purpose also can be said that to confirm whether haptic stimulations were appropriate for improving listening skills.

1.5. Contribution

This study contributed to clarify the effectiveness of haptic stimulations for English learning.

This study consists of a series of 3 experiments.

The first was intended to research the effectiveness of haptic stimulations for correct vowels listening of an English word. The finding of this study was that haptic stimulations rather became destructors because they occurred many times to emphasize vowels and might get rid of participants ' attention.

The second was conducted to examine the appropriate target of haptic stimulations. In this experiment, to which words haptic stimulations are effective was also tested: relatively familiar, new and unknown. This study brought a hypothesis that a haptic stimulation is effective for memorizing the stress position of new words.

The final one was conducted to check whether the hypothesis of the 2nd experiment was reliable or not. The results partially denied its reliability. However, it was not perfectly denied, and the stimulations may have a strong effect to impress or emphasize an unclear or obscure element of pronunciation. This study also succeeded in discussing the mechanism of the effect.

The finding through these experiments is that haptic stimulations can affect human memory like visual objects do and can be a new tool for learning pronunciation. Therefore, it will be expected to help learning of blind persons or persons with dyslexia, in addition to helping usual persons.

Nevertheless, it was also implied that the effect is limited and cannot defeat individual ability such as a sensitive ear or high ability of language.

Finally, these findings can help the research about English of a company and some KMD real projects.

Chapter 2
Related Works

2.1. Effective Ways of Language Learning

According to Teshima(2011), the current ways of learning do not seem to be effective, and new ways must be suggested.

According to Odisio(2018), a multisensory process is probably effective for language pronunciation, because it has more power to impress the correct way and will make it easier to remember [11]. In addition to this, Carreker and Birsh(2011) observes that multisensory learning is effective also for general language skills [12]. Recently, language learning with touch and gesture is expected to be researched [13].

To sum up, language learning with multiple senses, especially with haptic or embodied stimulations is expected.

2.2. Learning and Human Senses

When learning languages, many people will use audio tools and textbooks. Maybe, there are few people relying only on textbooks or only on audio tools. This may be an instinctive tendency of human beings.

Shams(2008) writes that the best way of learning may be a multisensory way because the surroundings of a human stimulate his/her multiple senses and his/her experience consists of multisensory memory [14].

In fact, Watson et al(2014) reports that persons with synesthesia can learn effectively [15]. Witthoft et al(2013) reports that this is because those who have synesthesia can associate the concepts and their images better because of the more representations they can feel than the ordinary [16].

These studies imply that human beings can learn things better in a multisensory way because it gives more essences to associate a new concept they are learning and images they have to it. This may contribute to embodying the concept and memorizing it better.

2.3. Haptic Stimulations and Language Learning

Along with the expectations for language learning with touch, some studies applying haptic stimulations to language learning were conducted.

Hwang and Cho(2012) reported that appropriate haptic stimulations on hand can improve listening skills. According to this study, with participants being exposed to haptic stimulations could discriminate English intonations better [17].

Jung et al(2016) observed that participants could discriminate Chinese 4 tones better with a vibrotactile device stimulating differently depending on each tone. They also report that this helped participants to remember the meanings of the words [18].

These studies imply that haptic stimulations can enhance listening ability, so it is possible that a vibrotactile device corrects participants ’ listening.

However, a study with a haptic device toward the strong habit of adding vowel of the Japanese has not been conducted. This habit is very strong and critical, so a study relating to this must be worth conducting.

Chapter 3
Approach

3.1. The Prototype of the Haptic Device

In the previous chapter, it is described that haptic stimulations can improve the learners ’ ability of listening languages, so, in this chapter, the structure of a prototype of the haptic device and experiment with it are described.

As written in the 1st Chapter, the Japanese have a critical problem of hearing English. They add vowels to clusters unconsciously [19], which may disturb correct English acquisition. A physiological psychological study with ERP implies that this is brain-level phenomenon [9] and is a very strong habit to correct.

However, there is no research with haptic stimulations regarding this strong habit. The device giving haptic stimulations to emphasize correct vowel positions must be worth being created and tested because, as described before, learning with the stimulations can affect learners better than usual ways. Additionally, this is not a problem of the Japanese if this is regarded as a matter of unpleasant effects of mother tongue toward learned languages.

In this section, the structure of the device, stimulations it gives, and the experiment with it are mainly described.

3.1.1 The Structure of the Device

The Fig3.1 is the images of the device.

This device has 3 key points: switch, CPU and the actuator. The switch is the copper board seen in the left of Fig3.1. When the experimenter touches this, electrical potential changes on its surface, and it activates the CPU, which vibrates the actuator in the blue tape seen in the right of Fig3.1.

Also, this device was able to be connected to a computer via USB-cable and the length of haptic stimulations was able to be changed by giving a binary file to the machine through the cable.

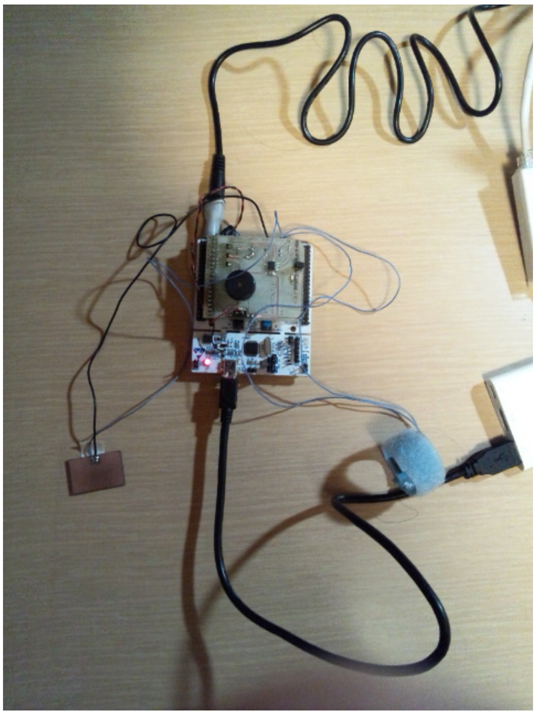

Figure 3.1 This is the device created for giving haptic stimulations.

3.1.2 The Object of the Device

This device was created to give haptic stimulations for notifying the correct positions of vowels.

It can generate haptic stimulations, which must be more sensible and clearer than visual ones or auditory ones. Therefore, it may contribute to fixing the Japanese habit of adding vowels to clusters, by indicating the correct positions of vowels in a word.

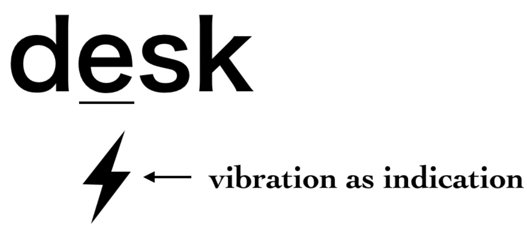

Figure 3.2 This is a description of how it will work. When a word (e.g. "desk") is pronounced, Japanese tend to hear it as [des*u*k*u*]), although its right pronunciation is like[desk]. If appropriate stimulations indicate the correct positions of vowels, the habit perhaps can be corrected.

3.1.3 The Vibrations

Next, very small experiment within 3 participants were conducted to decide what vibrations to use. 2 of them were exposed to sound of English words and various vibrations corresponding to their vowels. The vibrations were occurred by the experimenter ' s manual operations(Fig3.3).

Through this experiment, vibration length was decided to 100ms, because if it was longer than 100ms, vibrations got combined and could be felt as if it was continuously occurring when the pronounced words had several vowels. Contrary, if it was shorter than 100ms, the participants could not feel the vibration.

3.2. Experiment

3.2.1 Object

An experiment for confirming whether it is effective or not was conducted. The task used here was "vowels number detection". Strictly speaking, a task answering the positions of vowels is better, but to conduct that, participants must see or imagine the spelling, which becomes a very big hint of the correct answer. "Vowels number detection" cannot measure directly how a participant heard a word, but, if he/she could know the position of vowels, he/she probably can answer how many vowels existed, so it was conducted to examine the effectiveness.

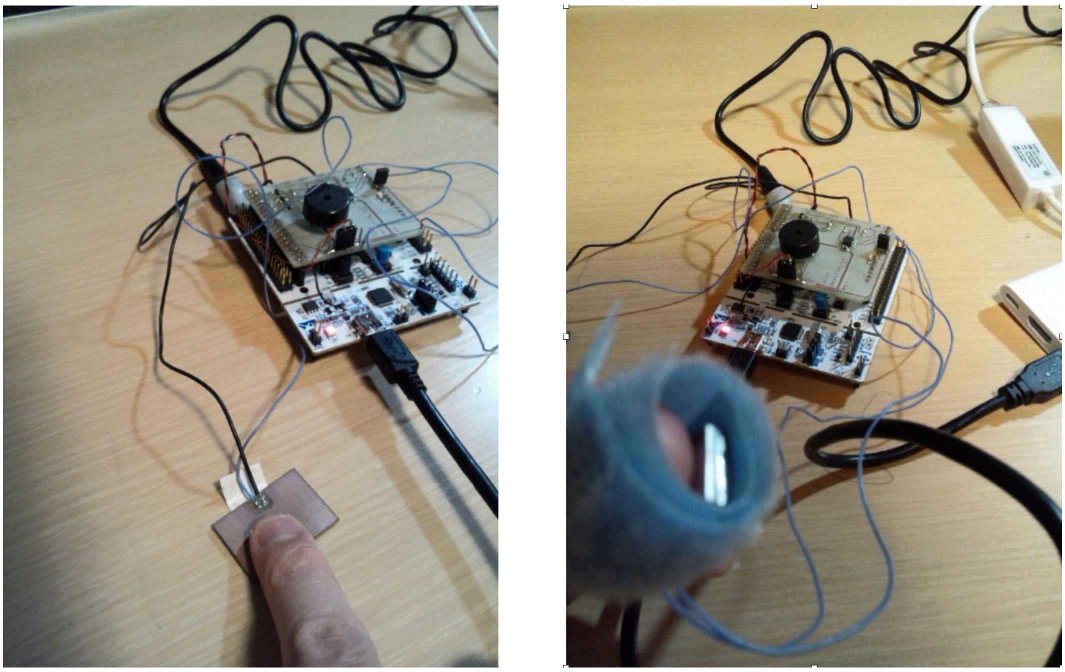

Figure 3.3 (Left) Vibrations were generated by the experimenter's touch to the copper board. (Right) Participants were required to wear the device on their forefinger, which is one of the most sensitive places in a human body.

In this experiment, participants were divided into 2 groups: control and experimental. Participants in the control group heard English words without the device and ones in the other heard words with it. By comparing the performance of vowels number detection, the effectiveness of the device was estimated.

3.2.2 Method

Participants

6 Japanese volunteers participated in this experiment (5 males and 1 female. Their mean age is 27.33 ± 7.48). They all were right-handed and did not have a disorder in eyes or ears. They were divided into 3 groups of English level, based on their scores of official English tests: A(Advanced, higher than 730 of TOEIC points), I(Intermediate, between 470 and 730) and B(Beginner, lower than 470). In each English level, the division of the groups were done. The first division based on English level is blocking to avoid a bias of English ability between the groups(Table 3.1).

Table 3.1 This indicates the number of participants of each condition and each English level. To make the effect of haptic stimulations clear, blocking based on English level was conducted.

English level	Experimental group	Control group
Advanced	1	1
Intermediate	1	1
Beginner	1	1

Stimuli and Setup

51 English words including at least one cluster were chosen as experimental stimuli because this experiment consisted of 3 sessions and each session needed 17 words: 4 easy words, 6 medium ones, and 7 hard words, based on Hwang and Cho(2012). All the words are randomly chosen from the book series of ”Sokudoku Sokucho Eitango[Vocabulary Building × Rapid Reading & Listening]” by

Z-Kai. Easy words are from the "Basic 2400" about the level of 500 points of the TOEIC, medium from "Core 1900" about 600 points to 800 points, and hard from "Advanced 1000" about 800 points to 900 points.

For the sound of each word, pronunciation from the database of "Oxford English Dictionary - The Definitive Record of the English Language - " was recorded. All the words were pronounced by males in a British way.

Figure 3.4 Words as experimental stimuli were chosen from these books.

The haptic stimulations were supplied by the device, and how it was manipulated was almost the same as described in 3.1.3.

The location of the experiment was in a quiet classroom. The experimental program was created and controlled with psychopy(v1.90.1) [20]. The used device was "MacBook Pro" with "macOS Sierra(v10.12.6)", 13-inch screen(2560 × 1600), the processing Units of "3.3GHz Core i7", the memory unit of "16GB 2133MHz LPDDR3" and graphics of "Intel Iris Graphics 550 1536 MB"

Procedure

Before the experiment, participants were required to read the consent document for participation and to give his/her signature if they can agree with the content.

At first, they answered personal questions about gender, age, handedness and English level.

After the questionnaire, the baseline test was conducted. In this session, all the participants listened to an English word and answered how many vowels it had contained within 3 seconds of time limits. To make this pure listening test, participants were told not to move their bodies and not to speak. After their answering, an interval whose length was randomly changed between 0.5 seconds and 1.5 seconds was inserted. Over 3 times practices, 17 questions were presented one by one. The order of these quizzes was randomized between subjects.

Next, the learning session was conducted. Participants were divided into the control group and the experimental group. For each English level, 1 participant was in the experimental group and the other was into the control one. Because the English level was divided into 3 levels, both experimental group and control group had 3 participants. In this session, a word and how many vowels it contains were shown along with it being pronounced. However, only to the experimental group, vibrations corresponding to vowels were given. It was repeated 17 times one by one in a pseudo random order, and the words in the baseline test did not appear here.

After the learning session, the final test was conducted. This was done in the same way as the baseline test. Also, here, all the displayed words became new to avoid making this experiment a memory test.

After finishing the final test session, participants in the experimental group were asked whether this device had been useful for improving listening of vowels or not.

Measurements

To evaluate the improvement of correctness after learning, each participant ’ s improvement score was calculated by subtracting the baseline test score from the final test score. This improvement scores were compared between two groups by t-test.

Also, to evaluate the improvement of judgement, each participant ’ s improvement response time(RT) was calculated by subtracting the baseline test RT from the final test RT. This improvement RT was compared between two groups by t-test.

Additionally, participants ’ feedbacks were treated as results.

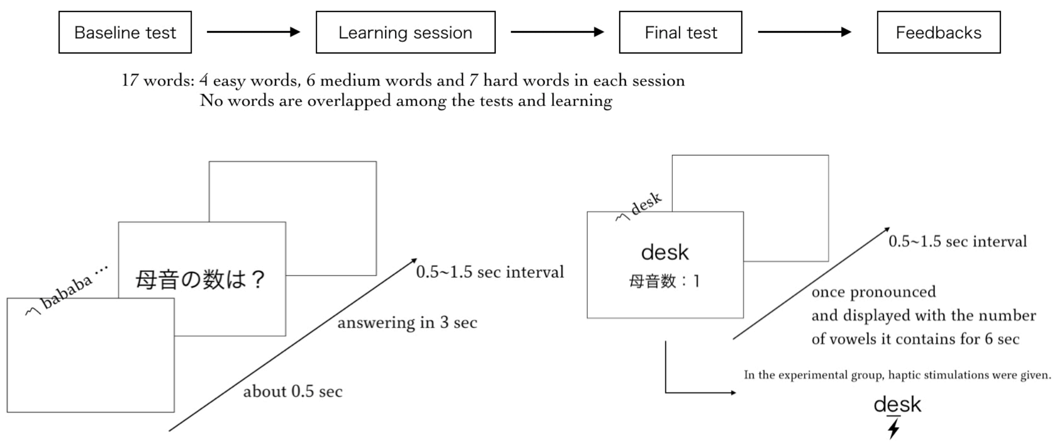

Figure 3.5 (Above) The flow of this experiment. (Left) This is the flow of one trial of the 2 test sessions. A word was pronounced once. Participants answered how many vowels were included in the word. (Right) This is the flow of one trial of the learning session. A word was pronounced once along with its spelling and the number of vowels it contains in 6 seconds. Participants in the experimental group learned the numbers of vowels with haptic stimulations.

3.2.3 Results

The followings are the results of this experiment. The average improvement of the number of correct answers in the experimental group is -1.000 ± 3.742, and that of the control group is 1.667 ± 3.269. The average improvement of RT in the experimental group is -0.494 ± 0.343, and that of the control group is -0.152 ± 0.463.

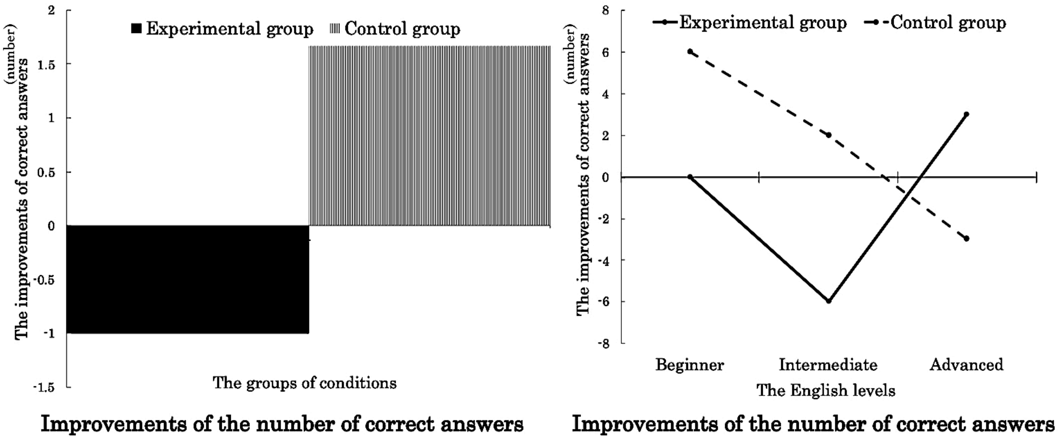

Figure 3.6 (Left) This indicates the improvement scores between the groups.. (Right) This indicates the improvement scores not only in terms of the groups, but also in terms of English level.

t-test for the improvement score was performed to the two groups and no significant difference was observed ($t_{(4)} = -.718, p = .512, d = .759$).

t-test for the improvement RT was performed to the two groups and no significant difference was observed ($t_{(4)} = -.838, p = .449, d = .838$).

For usability, 1 participant answered this was helpful during the learning session. However, the others answered this was not helpful.

3.2.4 Discussion

The results imply that haptic stimulations could not improve listening skill, and could not improve the judgement time, neither. This is contrary to the findings of previous studies [17], [18].

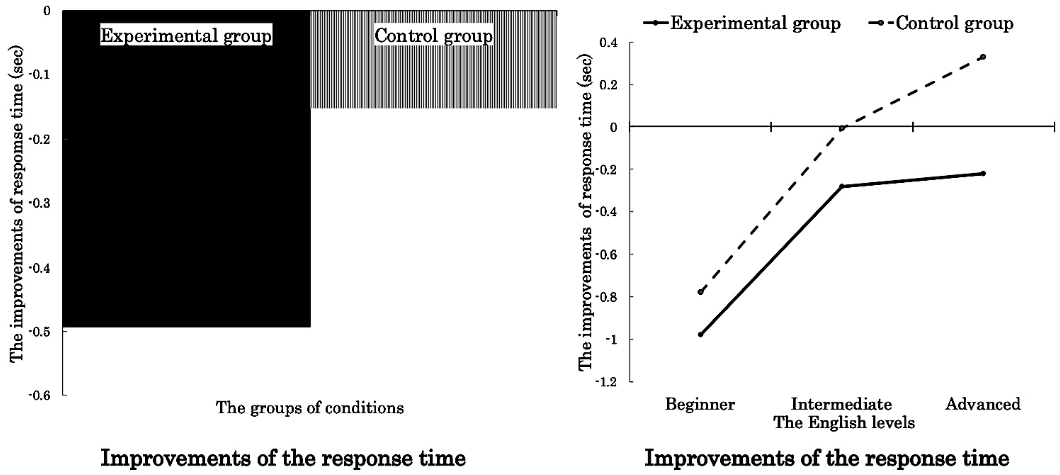

Figure 3.7 (Left) This indicates the improvement RT between the groups. The negative time means improvement of judgements. (Right) This indicates the judgement improvement not only in terms of the groups, but also in terms of English level.

The big differences between the present experiment and the previous studies are timing of haptic stimulations and the object. In this experiment, the stimulations were not given during the test session and this experiment was not intending to improve the skills of memorizing pronunciation or meanings, but to correct the Japanese habit of adding vowels when listening. Therefore, only 17 times exposure to multimodal learning is probably too short to change participants ' listening styles, which had been formed from their early ages.

However, because the sample number is small, the statistical analysis is not so reliable. Although the t is small and p is big, d is rather big, which implies that some effects of the stimulations surely exist. Therefore, examinations without statistical viewpoints also must be needed.

The obvious tendency easily seen is that participants in experimental group got lower scores than in the control group, which means that the haptic stimulations rather destructed listening. Although this may be because of 1 participant ' s improvement score of -6, 2 participants in the control group got positive improvement scores and 2 in the experimental group got 0 or negative improvement score.

Taking these into account, it is suggested that haptic stimulations might disturb participants.

Hwang and Cho(2012) reports that haptic stimulations destruct listening if they are inappropriately presented. It is because they cut participants' attention and concentration [17]. In fact, some participants notified that the stimulations are annoying and more than needed. These feedbacks may suggest that the stimulations were not effectively given and rather became destructors. One feedback supports this discussion. It was given by a participant, who is very familiar with English. The feedback is the following.

> This device does not allow me to hear English as it's really pronounced. For example, in English "schwa" exists, which is weakly pronounced. Of course, it must be heard vaguely because it is a vague vowel, but this tool also emphasized it and made me hear it stronger than as it is. Mechanical emphasis to all the vowels is obviously inappropriate.

Feedbacks like the above were given by 2 participants in the experimental group. These feedbacks probably mean that participants with haptic stimulations were gotten rid of attention. Kahneman(1973) observes that it is hard for human beings to pay attention to many stimulations and things at the same time because mental resources for attention is limited [21]. Due to the lack of attention, they could not learn English vowels well and resulted in getting lower scores. Probably haptic stimulations were not effective for accurate vowels listening because of its weak association with actual correct pronunciation.

Although the effectiveness of the haptic stimulations could not be observed in the present experiment, some interesting feedbacks were also collected. Some participants told that they could notice their incorrect listening styles with the device. They usually estimated that English words contain more vowels than the actual number, because they translate pronounced words into *katakana* English which vowels must be added to. Some of them said that this may become a useful tool for listening if the stimulations were displayed more appropriate.

Finally, the results related to RT seem to indicate that the experimental group responded quicker. However, considering the tendency of the improvement of the number of correct answers and 2 participants' feedbacks, it cannot be written that haptic stimulations helped participants.

Therefore, in this experiment, it is strongly suggested that there is no significant impact of simple emphasis of vowels of an English word.

3.3. What to Improve

Considering the results and feedbacks in the present experiment, the haptic stimulations must be improved.

The main thing to be improved is the timing of the haptic stimulations. This simple mechanical emphasis of all the vowels rather disturbs correct listening. Not to disturb their listening, limited numbers of appropriate stimulations are thought to be more appropriate.

Chapter 4
Design Iteration

4.1. A New Way of Emphasis

Since some problems were identified through the experiment in the previous section, efforts to eliminate them are needed. The big problem was too many stimulations to hear vowels in a word correctly. Because it emphasized more vowels than needed, a new way of giving haptic stimulations needs to be thought.

In the previous experiment, the participants who complained of the device did not assert it was ineffective at all. They both said that, emphasizing stress points might be appropriate because the haptic emphasis was very strong and could be a clear indication. These participants thought that the big problem was the emphasis on weak sounds, so it is natural for them to have this opinion. Additionally, this may be meaningful for improving English listening in terms of objective thinking not fully depending on participants ’ subjective opinion.

According to Shimaoka(1986), English is a language with “stress-timed rhythm” and the modulations between stressed positions and unstressed ones are important in a conversation [10]. Additionally, stress controls the part of speech and meaning of a word [22], and the Japanese are not good at stresses [7]. No.5 and No.7 in the Table 1.1 are directly related to the stress and No.2 and No.8 may have a relation.

Therefore, stress is also thought to be one important essence for English listening and the Japanese may have problems for it because stress point usually exists vowel. In other words, stress has a strong relation to vowels and may be hard to be understood by the Japanese. There are few researches on how to improve stress comprehension with haptic stimulations, and it may be worth conducting.

4.1.1 The New Device

The following is the new device enabling stress learning.

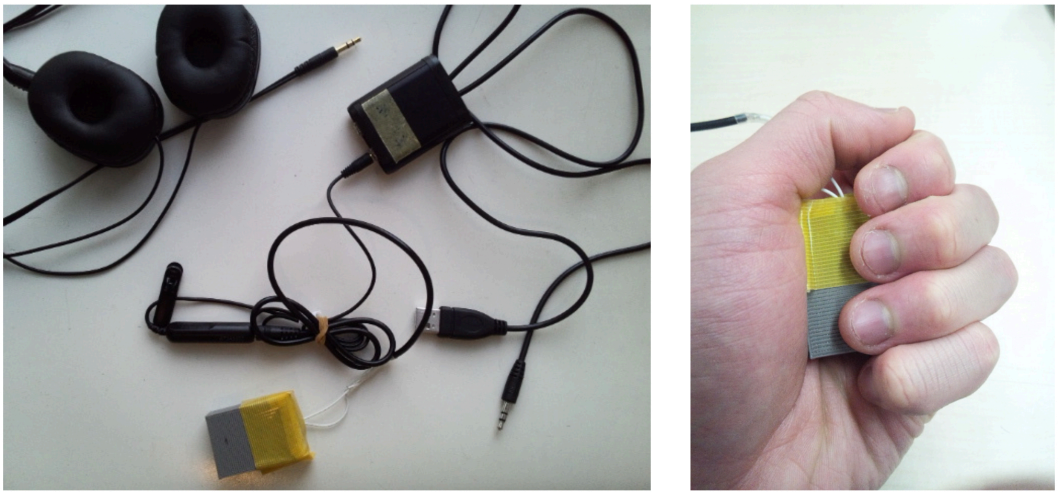

Figure 4.1 (Left)This is the new device created for giving haptic stimulations. (Right) To spread the field of somatosensory and give a few stimulations certainly, the actuator was designed to be grabbed

The big difference between this new device and the old one is that this does not need an operator. This device was created to emphasize the stress position, so the timing is more critical than to emphasize the number of vowels. It needs perfect controls for the timing of the haptic stimulations.

This works being connected to a computer via USB cable for charging and headphone cable to catch stereo sounds. The stereo sounds sent to its body -the small black box seen in the upper-right of Fig4.1- were separated into the right and the left. Then, the right one is converted to a monaural sound file and sent to headphones connected to the body. The left one is sent to the actuator in the gray box with yellow tape in the bellow of Fig4.1 and vibrates it. Therefore, if there is an appropriate stereo sound, it can vibrate corresponding to stresses in perfect control by a sound file.

4.1.2 The Sound and Haptic Stimuli

Both sounds and haptic stimulations were generated by stereo sound files.

The files for sounds and haptic stimulations were created with “Audacity 2.2.2”, which is a free sound editing software. For the haptic stimulations corresponding to stresses, a white noise to vibrate the actuator was inserted on the left channel. The length of the white noise was 100ms, same as the previous experiment, and started 50ms before the stress of a word. The stress point was identified carefully with watching spectrogram of the sound and listening to the sound. Contrary, for the sounds with no haptic stimulations, the left channel was set to be mute so that the actuator will never vibrate(Fig 4.2).

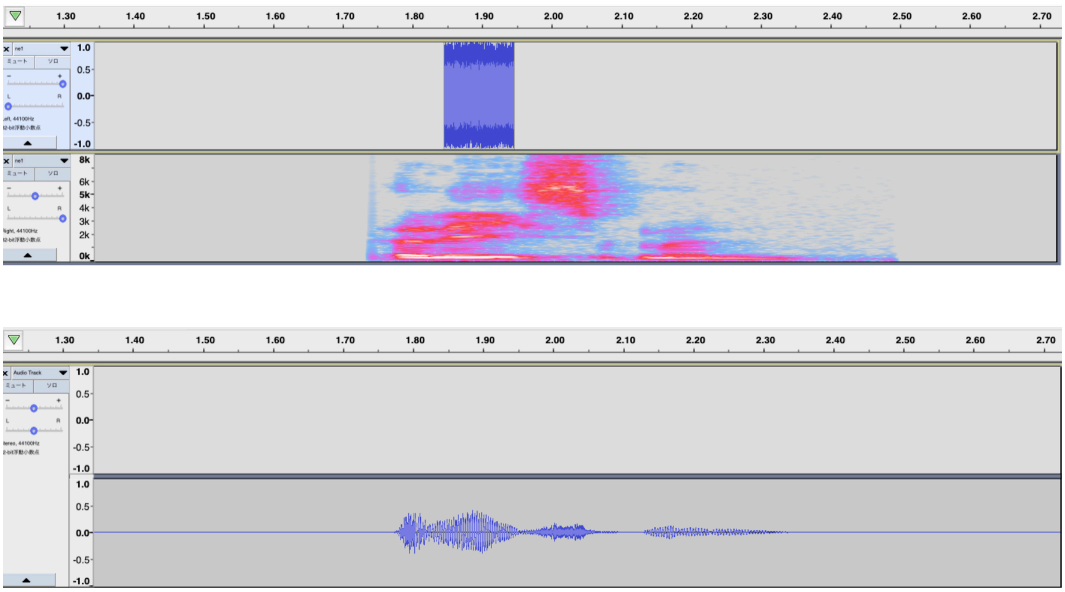

Figure 4.2 (Above)This is an image of a sound with a haptic stimulation corresponding to its stress. In the left part, 100ms white noise to vibrate the actuator was set beginning 50ms before the stress point. The stress point was detected by hearing and viewing spectrogram. (Bellow)An image of a sound with no haptic stimulation.

4.2. An Experiment with the New Device

4.2.1 Object

An experiment for evaluating the new device was conducted.

The device was intended to give more effective stimulations for detecting stresses in a word, so the task used for this experiment was “stress position detection”. Like the previous experiment with “vowels number detection”, this consisted of the baseline test, the learning session and the final test. The measurements were almost the same as the previous: the improvement score and the improvement RT. By comparing these values between groups, the effectiveness of the device should be examined.

4.2.2 Variations of Experiment

This experiment has some versions to clearly the effect of haptic stimulations(Table4.1).

Table 4.1 This experiment had 3 versions depending on words as stimuli, and what the versions could imply by positive results is also different.

	Baseline Test	Learning Session	Final test	What will be implied by haptic group’s improvement
v1	Word Set 1	1	1	effectiveness of haptic stimulations
v2	Word Set 1	Word Set 2	2	effectiveness of haptic stimulations
v3	Word Set 1	1	Word Set 2	effect of haptic stimulations for participants’ listening style

v1 measures the effectiveness for pure stress leaning。The same words as stimuli appeared in all the sessions. The advantage of v1 is that it uses the same words, both for baseline and for the final, which makes it very clear that participants got affected if results difference between groups are observed. However, participants will be habituated with words due to frequent exposure.

v2 solved this problem by avoiding using the same words for the baseline test and the final test, but, when the participants in the experimental group got the higher score, the effectiveness for the improvement is not asserted because it is possible that the improvement is due to the change of words.

Finally, v3 is to measure an effect for listening style. In its final test, participants were tested with new words, but, if they could learn the definition or image of a stress, they will be able to answer them correctly. The previous experiment implied that haptic stimulations will not affect the participants ’ listening style for vowels number detection, but an effect for listening style for stress position detection may be worth researching.

4.2.3 Method

Participants

6 Japanese volunteers participated in this experiment (male : female = 6 : 0. Their mean age was 25.00 ± 0.98). One of them was left-handed and they all did not have a disorder in eyes or ears. They were asked about English level based on their scores of official English tests and divided into 3 groups of A, I, and B based on the scores in the same way as of the previous experiment, but blocking based on it was not conducted.

Stimuli and Setup

40 English words with 4 vowels including “ y ” , pronounced as a long vowel, in their spelling were selected as stimuli and they all had only 1 stress point. They were divided into 2 word sets and 1 set consisted of 5 easy words, 7 medium ones, and 8 hard ones. All the words were randomly chosen from the book series of "Sokudoku Sokucho Eitango" and the selection rule was the same as the previous experiment.

For the sound of each word, pronunciation was recorded from the database of “ Oxford English Dictionary - The Definitive Record of the English Language - ” . All the words were pronounced in a British way, by both males and females.

Each sound file was processed with “ Audacity 2.2.2 ” in the way described in 4.1.2.

The experimental location, the software and the device used for this experiment were the same as the previous experiment.

Procedure

Before this experiment, participants were required to read the consent document for participation and to give his/her signature if they could agree with the content.

At first, they answered personal questions about gender, age, handedness and English level.

After the questionnaire, the baseline test was conducted. In this session, all the participants listened to an English word through headphones and answered the correct position of the stress from 4 alternatives within 6 seconds of time limits. To make this pure listening test, participants were told not to move their bodies and not to speak. After answering, an interval whose length was randomly changed between 0.5 seconds and 1.5 seconds was inserted. After 3 times practices, 20 questions were presented one by one. The order of these quizzes was randomized between subjects.

Next, the learning session was conducted. Participants were divided into the control group and the experimental group. In this session, a word and its correct stress position were shown with it being pronounced. However, only to the experimental group, a vibration corresponding to the stress was given. A word and its stress position were presented 20 times one by one in a random order.

After the learning session, the final test was conducted. This was done in the same way as the baseline test.

After finishing the final test session, participants in the experimental group were asked to give feedbacks as they liked.

In this experiment, one participant underwent 2 different versions to compensate the lack of participants, but they did not become participants of the other group. To minimize the factorial confounding, the order of undergoing session was counterbalanced.

Measurements

To evaluate the improvement of correctness after learning, each participant ’ s improvement score was calculated by subtracting the baseline test score from the

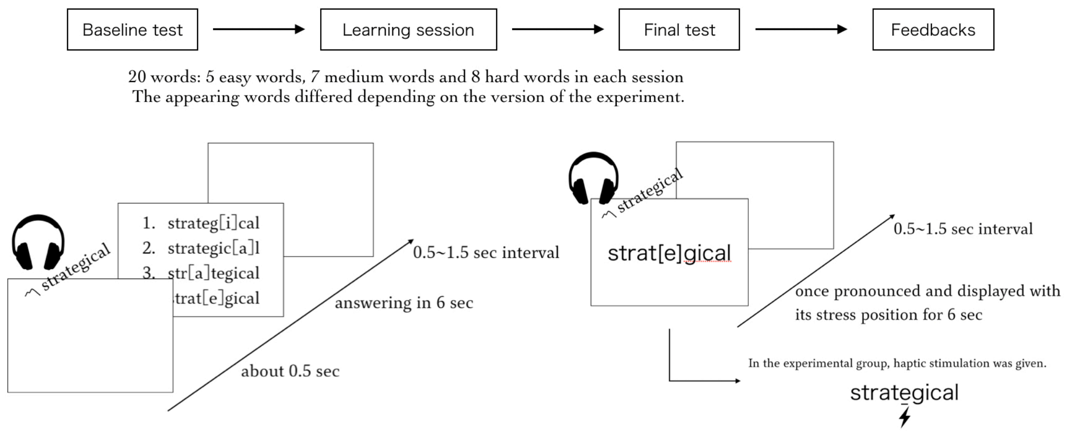

Figure 4.3 (Above) The flow of this experiment. (Left) This is the flow of one trial of test sessions. A word was pronounced once. Participants answered the stress position. (Right) This is the flow of one trial in learning session. A word was pronounced once along with its spelling and its stress position in 6 seconds. Participants in the experimental group learned the stress position with haptic stimulations.

Table 4.2 This indicates the each participant's experimental order. Because it was inevitable that ordering effect and factorial confounding would occur due to the lack of word sets, effort to minimize it had to be needed.

	haptic			non-haptic		
	v1	v2	v3	v1	v2	v3
p1	1st	2nd	-	-	-	-
p2	-	-	-	1st	2nd	-
p3	-	-	-	2nd	-	1st
p4	-	1st	2nd	-	-	-
p5	-	-	-	-	1st	2nd
p6	2nd	-	1st	-	-	-

final test score.

Also, to evaluate the improvement of judgement, each participant ' s improvement response time(RT) was calculated by subtracting the baseline test RT from the final test RT.

In this experiment, statistical analysis was not performed because the number of participants is very small.

4.2.4 Results

The followings are the results of this experiment.

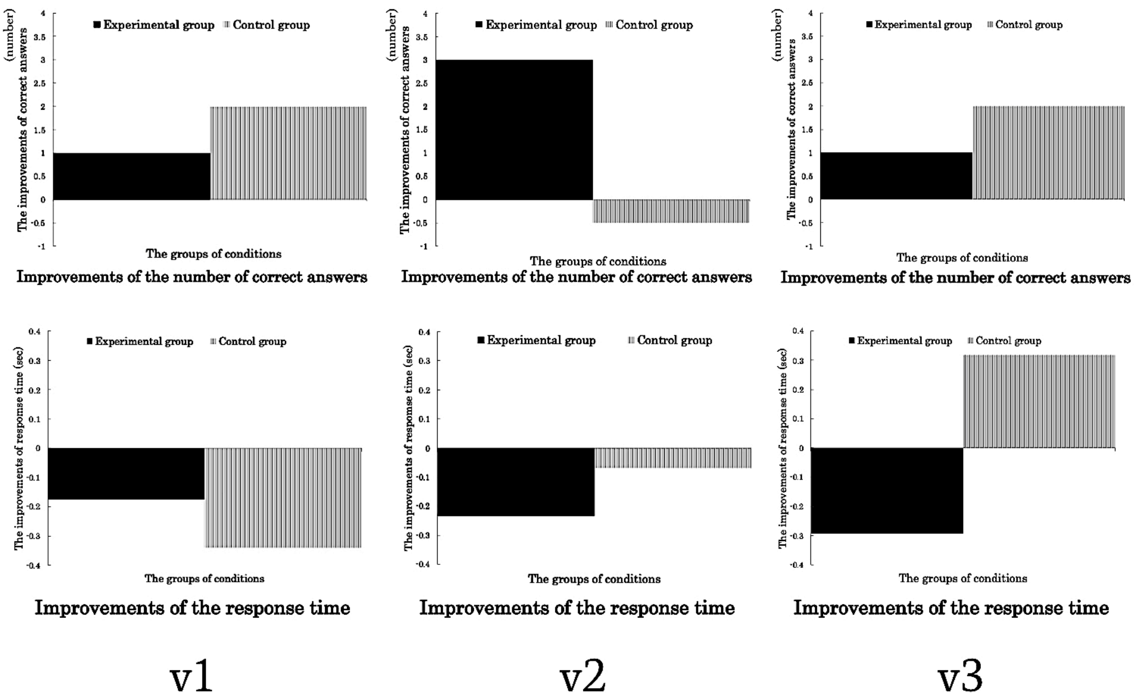

Figure 4.4 (Left) The results of v1. (Middle) The results of v2. (Right) The results of v3.

In v1, the average improvement of the number of correct answers in the experimental group was 1.000 ± 1.414, and that of the control group was 2.000 ± 1.414. The tendency of the number of correct answers was the same in the 2 groups and the control group seems to have answered more correctly than the experimental one. The average improvement of RT in the experimental group was -0.174 ± 0.894, and that of the control group was -0.340 ± 0.217. The tendency of RT was also the same in the 2 groups and the control group responded quicker than the experimental one.

In v2, the average improvement of the number of correct answers in the experimental group was 3.000 ± 2.829, and that of the control group was -0.500 ± 2.121. The tendency of the correct answer number differs between the 2 groups. The experimental group answered more correctly than the control one. The average improvement of RT in the experimental group was -0.237 ± 0.442, and that of the control group was -0.069 ± 0.006. The tendency of RT was the same in the 2 groups, but the experimental group seems to have answered quicker than the control one.

In v3, the average improvement of the number of correct answers in the experimental group was 1.000 ± 4.243, and that of the control group was 2.000 ± 1.414. The tendency of the number of correct answers was the same in the 2 groups and the control group seems to have answered more correctly than the experimental one. The average improvement of RT in the experimental group was -0.294 ± 0.074, and that of the control group was 0.319 ± 0.592. The tendency of RT differs between 2 groups and the experimental group responded quicker than the control one.

4.2.5 Discussion

About v1, judging from the number of correct answers, the haptic stimulations do not seem to help participants to learn the position of stress. This stimulation may not be useful for words which participants are familiar with. The reason may be hearing and seeing is enough for learning the position of stress for familiar words and haptic stimulations might disturb participants concentrations like the previous experiment. Additionally, RT is also longer in the experimental group, so the stimulations probably became destructors here.

About v2, the number of correct answers increased, and RT got shorter in the experimental group. These suggest that haptic stimulations can be useful for encoding or remembering the stress position of new words.

About v3, because the number of correct answers decreased in the experimental group, it is suggested that haptic stimulations are not strong enough to affect each participant's listening style. However, RT got obviously shorter, which may imply the stimulations succeeded in giving vague images of stresses, but a positive result is not observed in the number of correct answers. Therefore, it cannot be said that it is effective for understanding the core features of stresses.

Focusing on each participant's score, one whose English level is B(Beginner) got the highest improvement of +5.000 in the number of correct answers in v2 with the device. This may suggest that the device is effective for English beginners to understand word stresses.

However, some feedbacks make this discussion dubious. They are like, "Stress emphasis by "[ ]" (brackets) in words was very useful and I mainly counted on them."

In this experiment, the power of the brackets cannot be calculated because they were not a factor, so it cannot be asserted that the haptic stimulations are surely useful for encoding or recalling the stress position.

4.2.6 Conclusion

This experiment implied that haptic stimulations are effective for understanding the stress position of new words, especially for beginners, but it must be examined carefully.

4.3. A Confirmative Experiment

4.3.1 Object

This experiment was conducted to clarify whether the haptic stimulations are effective for understanding the stress position in a word.

The previous experiment with the new device implied its effectiveness for detecting stress positions especially for English beginners. However, in the experiment, the stress position was always emphasized by a couple of brackets, and some participants seemed to refer to them much. Therefore, it should be clear whether the improvement was brought by haptic stimulations or visual emphasis.

4.3.2 Method

Participants

16 Japanese volunteers without a disorder in eyes or ears participated in this experiment and none of them had participated in the previous experiment (male : female = 8 : 8. The mean age was 25.13 ± 3.99. All of them were right handed). During the experiment, mechanical trouble occurred in one participant's session and she was eliminated from the analysis.

They were asked about English level based on their scores of official English tests and divided into 3 groups of A, I, and B based on the scores in the same way as the previous experiments. Each group contained 5 participants (Actually, 6 had belonged to the group A, but one was eliminated from the analysis.).

Stimuli and Setup

80 English words with 4 vowels including "y", pronounced as a long vowel, in their spelling were selected as stimuli and they all had only 1 stress point. They were divided into 4 word sets and 1 set consisted of 5 easy words, 7 medium ones, and 8 hard ones. All the words were randomly chosen from the book series of "Sokudoku Sokucho Eitango" and the selection rule was the same as the 2 previous experiments.

For the sound of each word, pronunciation was recorded from the database of "Oxford English Dictionary - The Definitive Record of the English Language -".

All the words were pronounced in a British way by both males and females.

Each sound file was processed with “ Audacity 2.2.2 ” in the way described in 4.1.2.

The location of the experiment was in a quiet place in a corridor. The experimental program was created and controlled with psychopy3(v3.1.2) [20]. The used device was ”DELL XPS” with ”Windows10 Pro”, the processing Units of ”2.4GHz Core i7-5500U” and the memory units of ”8.0GB ”.

Procedure

Before the experiment, participants were required to read the consent document for participation and to give his/her signature if they could agree with the content.

At first, they did the level check test of “ Cambridge Assessment English ” to estimate the present English level on its website [23]. In this experiment, an effect of English ability of each participant is also examined and this web test was done to know it accurately. After this, they answered the questionnaire on personal information.

Next, how to participate were explained and 3 times practice were conducted. To make this pure listening test, participants were told not to move their bodies and not to speak. After confirmations of whether they understood how to do, the learning and test sessions began.

20 words were presented to be leaned one by one, and after that, stress detecting tests on the learned words were performed in the same way as the previous experiment. Every time a participant finished the learning session, a test session of the 20 words learned just before started. After finishing the test session, interval for his/her break was inserted. This was repeated 4 times, so participants would see 80 words and did 80 quizzes of the test.

However, the ways of presentation in the learning session were different. There were 4 ways: with both the vibration and the brackets, without the vibration but with the brackets, with the vibration without the brackets, and without both the vibration and the brackets.

In this experiment, each participant underwent 4 learning sessions, and the session order was counterbalanced.

After finishing this experiment, participants answered usability questions of

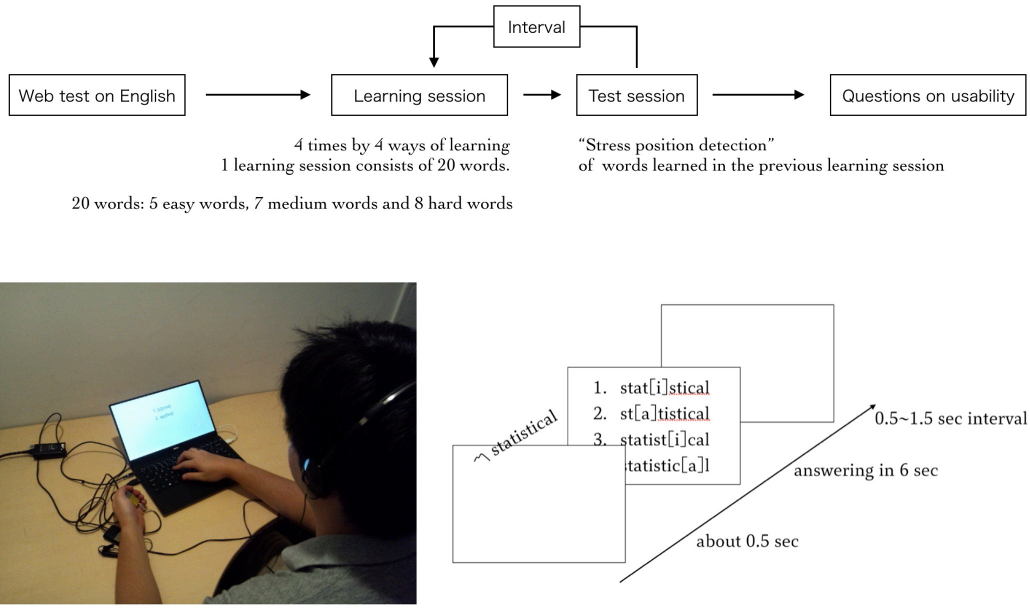

Figure 4.5 (Above) The flow of this experiment. (Left) This is how participants did. (Right) The stress detection was done in the same way as the previous experiment.

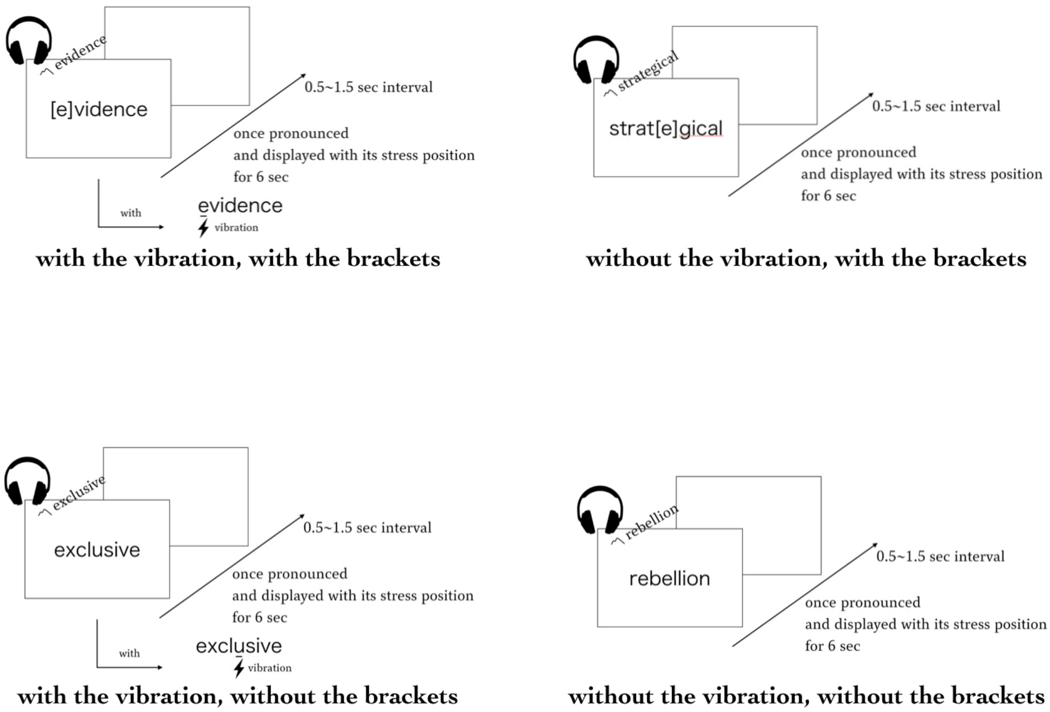

Figure 4.6 (Upper-Left) In this condition, words were presented with both the vibration and the brackets. (Upper-Right) In this condition, words were presented with the brackets, but without the vibration. (Lower-Left) In this condition, words were presented with the vibration but without the brackets. (Lower-Right) In this condition, words were presented with neither the vibration nor the brackets.

“ How much was the vibration useful to encode the position of stress? ” ,
” How much was the vibration useful to recall the position of stress? ” and
“ How much was the vibration useful to acquire the rhythm of English? ” .
Participants answered with a 1-7 scale for all these questions (1 means not useful at all, and 7 means very much useful.).

Measurements

The points of the web check on English Level, the number of correct answers, the response time(RT) in each condition and answers for usability scales were measured.

The number of correct answers and RT were analyzed in the mixture-design 3 factorial ANOVA (between-subject: English level assumed by official test(A / I / B), within-subject: Haptics(with / no) and Emphasis by the brackets(with / no)), and the points of the web check and the usability scale was analyzed in between-subject ANOVA by English Level(A / I / B).

Additionally, correlation analysis on the numeric results was performed.

4.3.3 Results

The results on the number of correct answers and response times are shown in Fig4.7.

According to ANOVA for the numbers of correct answers, there were no significant differences in all the main effects and interactions (English level ($F_{(2,12)} = 1.860, p = .198, partial\,\eta^2 = .237$), Haptics ($F_{(1,12)} = .416, p = .531, partial\,\eta^2 = .033$), Emphasis ($F_{(1,12)} = 1.090, p = .317, partial\,\eta^2 = .083$), English level * Haptics ($F_{(2,12)} = .313, p = .737, partial\,\eta^2 = .050$), Haptics * Emphasis ($F_{(2,12)} = .555, p = .471, partial\,\eta^2 = .044$), Emphasis * English level ($F_{(2,12)} = .550, p = .591, partial\,\eta^2 = .084$), English level * Haptics * Emphasis ($F_{(2,12)} = .362, p = .053, partial\,\eta^2 = .707$),

According to ANOVA for RT, there was a significant difference in English level ($F_{(2,12)} = 6.747, p = .011, partial\,\eta^2 = .529$), and Tukey's multiple comparison detected that the significant difference lay between A and B ($p = .010$). Also, the main effect of Haptic had a significant difference ($F_{(1,12)} = 5.052, p =$

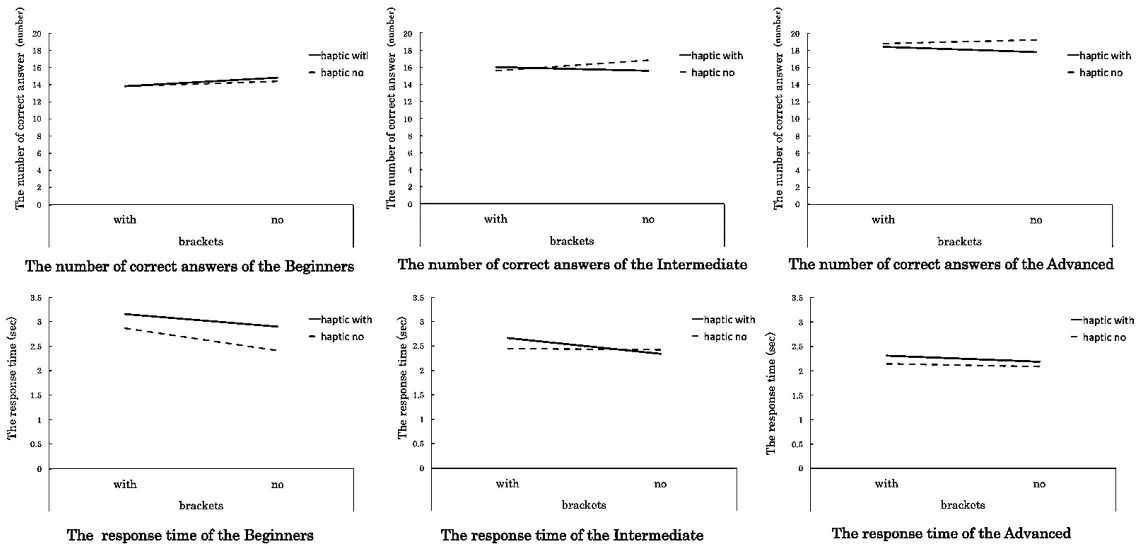

Figure 4.7 These graphs indicate the results of the tests. The left is those of the beginners, the middle is of the intermediates and the right is of the advanced. (Upper) These graphs indicate the number of correct answers of each English level. (Lower) These graphs indicate the response times of each English level.

$.044, partial\,\eta^2 = .296$). Additionally, the main effect of Emphasis was significant, too ($F_{(1,12)} = 12.280, p = .004, partial\,\eta^2 = .506$). However, all the interactions were not significant (English level * Haptics ($F_{(2,12)} = 1.259, p = .319, partial\,\eta^2 = .173$), Haptics * Emphasis ($F_{(2,12)} = .197, p = .665, partial\,\eta^2 = .016$), Emphasis * English level ($F_{(2,12)} = 1.732, p = .218, partial\,\eta^2 = .224$), English level * Haptics * Emphasis ($F_{(2,12)} = 1.331, p = .301, partial\,\eta^2 = .182$),

Results on Usability are shown in Fig4.8.

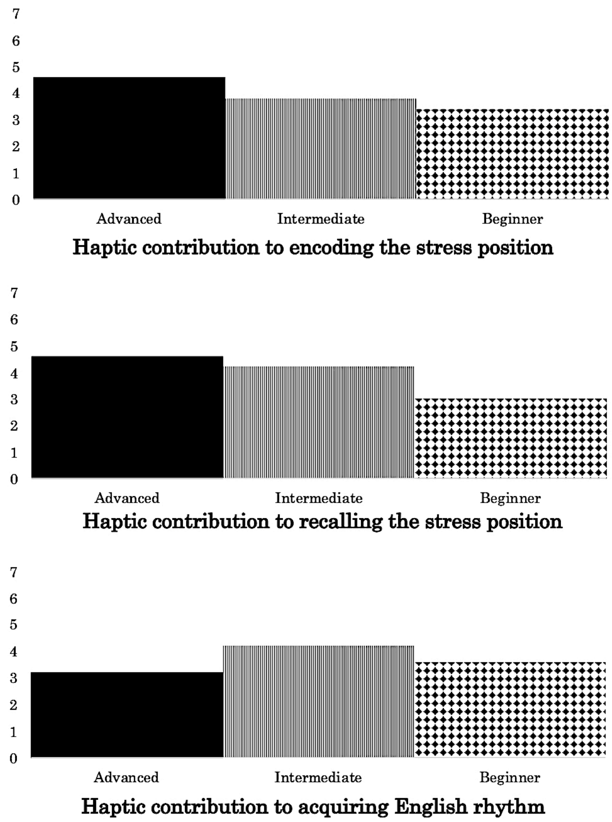

Figure 4.8 These graphs indicate the usability and usefulness of the device in terms of English levels.

The mean score for feeling the device was useful to encode the stress position is 3.93 ± 1.39 and no significant difference was observed($F_{(2,12)} = .966, p = .408, partial\,\eta^2 = .139$).

The mean score for feeling the device was useful to recall the stress position is 3.93 ± 1.49 and no significant difference was observed($F_{(2,12)} = 1.733, p = .218, partial\,\eta^2 = .224$).

The mean score for feeling the device was useful to acquire English rhythm is 3.66 ± 1.10 and no significant difference was observed($F_{(2,12)} = .905, p = .431, partial\,\eta^2 = .131$).

The points of the web test of "Cambridge Assessment English" is shown in Fig 4.9, and there was a significant difference in English level($F_{(2,12)} = 12.713, p = .001, partial\,\eta^2 = .679$). By Tukey's multiple comparison, the difference was observed between A and I($p = .017$), and A and B($p = .001$).

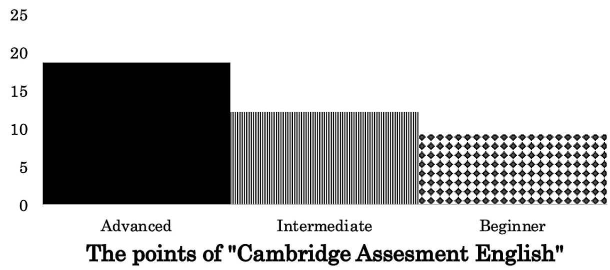

Figure 4.9 This graph indicates the points of "Cambridge Assessment English" in terms of English levels.

Finally, the correlations among the numeric results: "Web test point", "The number of correct answers of each participant", "The RT of each participant", "Haptic contribution to encoding", "Haptic contribution to recalling" and "Haptic contribution to English rhythm", were examined. The results are indicated by the Table 4.3 and the following combinations had strong correlations.

· Web test point - The RT of each participant
($r = -.789, p < .001, r^2 = .623$),

· Haptic contribution to encoding - Haptic contribution to recalling
($r = .933, p < .001, r^2 = .870$),

The following combination had a significant correlation

· The number of correct answers of each participant - The RT of each participant
($r = -.622, p = .013, r^2 = .387$),

Finally, the following combinations had marginally significant correlations.

· Web test point - The number of correct answers of each participant

$(r = .490, p = .064, r^2 = .240)$,
· Web test point - Haptic contribution to encoding
$(r = .443, p = .098, r^2 = .196)$,
These significant and marginally significant correlations are also indicated by Fig 4.10.

Table 4.3 The correlations among numeric results.

	Web test point	The number of correct answers of each participant	The RT of each participant	Haptic contribution to encoding	Haptic contribution to recalling	Haptic contribution to English rhythm
Web test point	$r = 1$ $n = 15$	$r = .490$ $p = .064$ $n = 15$	$r = -.789$ $p < .001$ $n = 15$	$r = .443$ $p = .098$ $n = 15$	$r = .423$ $p = .116$ $n = 15$	$r = -.412$ $p = .127$ $n = 15$
The number of correct answers of each participant		$r = 1$ $n = 15$	$r = -.622$ $p = .013$ $n = 15$	$r = -.041$ $p = .886$ $n = 15$	$r = -.063$ $p = .823$ $n = 15$	$r = -.044$ $p = .876$ $n = 15$
The RT of each participant			$r = 1$ $n = 15$	$r = -.145$ $p = .605$ $n = 15$	$r = -.128$ $p = .648$ $n = 15$	$r = .355$ $p = .194$ $n = 15$
Haptic contribution to encoding				$r = 1$ $n = 15$	$r = .933$ $p < .001$ $n = 15$	$r = -.190$ $p = .498$ $n = 15$
Haptic contribution to recalling					$r = 1$ $n = 15$	$r = -.136$ $p = .628$ $n = 15$
Haptic contribution to English rhythm						$r = 1$ $n = 15$

4.3.4 Discussion

The web test points differed by the English level. This means that the division by English level was done appropriately, especially for separating the advanced from the others. Although, the web test points do not differ between the intermediate and the beginners, the point is corresponding to English level, so the division was successfully done.

The results on the number of correct responses imply that haptic stimulations did not play an important role in improving task performance.

The results on RT implied that participants with higher English skills responded quicker than with lower skills, haptic stimulations delayed answering responses, and emphasis by the brackets also delayed responses. This may sound that vibrations rather became destructor, too, but this idea is probably inaccurate, because haptic stimulations did not decrease the number of correct responses.

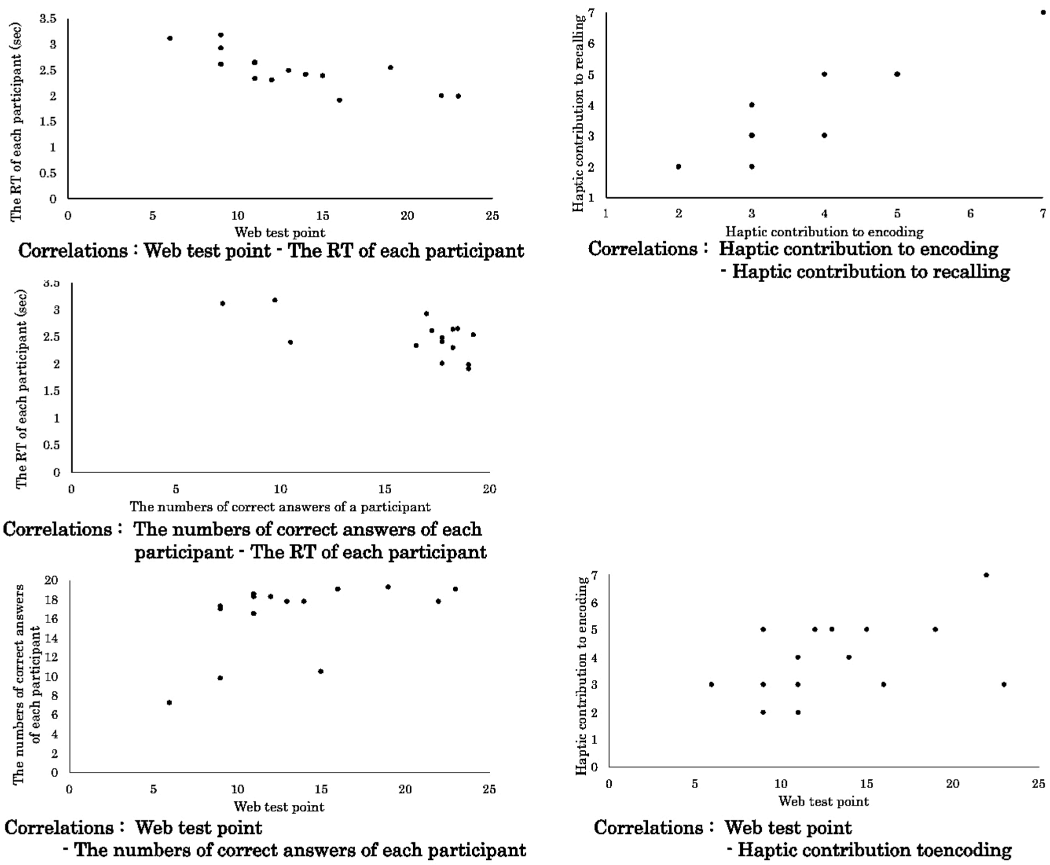

Figure 4.10 These graphs indicate the scatter plots of significant correlations. (Above) Particularly strong correlations. (Middle) Significant correlations. (Bottom) Marginally significant correlations.

The reason why the RT got longer under with-haptic level and with-emphasis level may be their validness for recalling. Some participants gave feedbacks like the following.

> Under the learning session with vibrations and the brackets, I noticed I misremembered the stress positions, so I took the test recalling the right positions of stresses.

This feedback suggests that Haptic and Emphasis made the participants think before answering, contrary to the conditions where they did not appear or stimulate, and participants answered only relying on their thoughts and guesses. They required participants to recall, in other words, to refer memory, and it resulted in the delay of responses. Therefore, haptic stimulations could give memorable information on the word stresses as visual indications do. Along with the experiment, it may be suggested that learning language stresses or pronunciations can be learned more effectively with haptic stimulations.

However, the most obvious results of correct responses were not observed. It may be because the biggest factor for performing this task better is individual listening ability. If a participant has high English ability or a sensitive ear for stresses, he/she can perform well no matter haptic stimulations occur. This assumption is supported by the negative correlation between web test point and each participant's RT, the negative correlation between the number of each participant's correct response and each participant's RT, the positive correlation between the number of each participant's correct response and web test point, and the quickest responses of the group A ' s. These suggest that participants with high English ability can respond quicker and more correctly than with beginner ' s ability of English. It means that the performance of this task strongly depends on personal factors: English ability or sensitive hearing.

There is no difference between groups in the values for usability, so the strong effectiveness for English beginner was not observed here. Because, according to Fredembach(2009), it is implied that audio-visual learning style is appropriate for most adults, it is possible that almost all the participants did not feel its usefulness and no difference was observed. However, the learning style is a very individual matter and there may be a person being able to learn well with haptic stimulations.

In fact, some participants evaluated the device highly for encoding stresses and recalling. This means that some participants felt the vibrations useful, and one thinking it was useful in the learning session tended to think it was also useful in the test session. This must be the cause of the strong correlations between these values and it indicates that an appropriate learning way varies among persons.

Finally, for web test point and haptic contribution to encoding, it can be a spurious relationship taking statistical values, which mean this correlation is weak, into account, but it might be possible that a person with high English ability can concentrate on the test regardless of the vibrations. As described, the web test may be directly related to English level of this experiment and participants in the group A are familiar with English. According to Mori(2005), when a person is doing an easy or a familiar task, the processing was automatized and not much cognitive resources are needed [24]. Therefore, this positive correlation perhaps means that the group A participants were not disturbed by the vibrations because they are familiar with English and thought the stimulations to be useful.

4.3.5 Conclusion

This experiment implied that the strong effectiveness of haptic stimulations observed in the previous experiment was by chance, but also implied that they have strong impacts to notify and impress the stress positions, and they can contribute to a learner ’ s careful thinking.

Chapter 5
Conclusion

5.1. The Findings through This Study

These experiments were conducted to clarify the effectiveness of haptic stimulations for better English listening, and it was found that haptic stimulations are not strong enough to change the learners' performances of some tasks because it is strongly affected by individual ability and senses, but there will be a possibility that haptic stimulations can emphasize critical parts of pronunciation.

Some may think that there are few new findings because some previous studies reported the effectiveness of multisensory learning [11], [12]. However, the present study implied that simple haptic stimulations can affect a human's memory, mind and how they think similarly to visual stimuli. Additionally, the present study did not only find an effect of multisensory learning, but also implied its mental mechanism. Although the present study has many elements to improve, these findings are probably interesting in terms of both technological science and basic science,

5.2. Implications

In this study, the potential power of a haptic stimulation was observed. It can be a strong cue to emphasize obscure elements. Therefore, for example, it can be an instruction for a pronunciation that learners are unfamiliar with.

Additionally, the last experiment implied that this can impress the position of the stress similarly to visual emphasis. Then, this can become an educational tool for blinded persons or persons who cannot read.

In this way, haptic stimulations have potential possibilities to be a new way of language learning. These stimulations can emphasize a vague element unidentifiable with ears or eyes, or can be instructions for people who are hard to undergo usual educations. In fact, the validity of multisensory learning for disordered people was reported [25], [26].

Haptic stimulations may not have a direct power to enhance or change a person' s ability, but it was implied that it can be a new tool for media or educational technologies because it probably has power to transport information.

5.3. Limitations for Future Works

Although this study examined the effectiveness of haptic stimulations in several ways, there are many essences to improve.

The first is the problem on participants. In this study, all the participants were students of an under-graduated school, who probably have been trained English for a long time. If the experiments were conducted within children or other persons, the result might differ. Actually, the study claiming the superiority of audio-visual for adults already exists [27], and one participant in the first experiment gave the following feedback.

> This device is not useful for me, because I already have my own listening style, so it is interesting if this is tested for children not exposed to English and not having their own English listening styles.

Therefore, in terms of psychological view and human development, an experiment within children or persons not having learned English may be worth conducting.

The second is a problem in the design of this experiment. This was done in a laboratory-like environment in about 40 minutes. However, usual learners do not study in this environment and usual learning aims to memorizing for a long time. This study could measure only a small part of a human memory. Thus, related studies in a realistic environment or confirming the effectiveness to another aspect of memory must be required.

The third is limited applications of results. Even if the effectiveness for listening and memorizing is implied, possible applications will be strongly limited. Along with Otsu(2009), listening can be a key to language acquisition, studies relating to further steps of language, such as whether haptic language learning can improve speech, would be needed.

Additionally, if it is shown that haptic stimulations help learners with correct speech, it does not mean improvements in communication in a language. Otsu(2009) also writes that para-languages play an important role in communication. They are elements associating with languages, such as properties of voices, tonalities and intonations, breathing between words, mimicry of voices or other elements [8]. Since acquiring a correct language is one thing and communicating with it is another, it is unsure whether the haptic stimulations can improve communications. Researches on haptic stimulations and effective communications are also expected.

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Appendices

A. Words Used in the 1st Experiment

Table A.1 This word set was used in the baseline test of "vowels number detection" in the 1st experiment.

Level	Words	Correct Answers
Easy	airplane	2
Easy	raspberry	3
Easy	subway	2
Easy	Christmas	2
Medium	harmful	2
Medium	commitment	3
Medium	regret	2
Medium	tactics	2
Medium	ultimate	3
Medium	neglect	2
Hard	abbreviate	4
Hard	efflux	2
Hard	intrinsic	3
Hard	membrane	2
Hard	subsistence	3
Hard	viscous	2
Hard	protectionist	3

Table A.2 This word set was used in the learning session in the 1st experiment.

Level	Words	Correct Answers
Easy	garden	1
Easy	gift	1
Easy	toast	1
Easy	classroom	2
Medium	seldom	2
Medium	muscular	3
Medium	establish	3
Medium	offspring	2
Medium	lecture	2
Medium	trade	1
Hard	kidney	2
Hard	fitful	2
Hard	optical	2
Hard	clandestinely	4
Hard	wilderness	3
Hard	testify	3
Hard	nocturnal	2

Table A.3 This word set was used in the final ”vowels number detection” task in the 1st experiment.

Level	Words	Correct Answers
Easy	interesting	4
Easy	circle	1
Easy	table	1
Easy	experience	4
Medium	conduct	2
Medium	branch	1
Medium	statistics	3
Medium	wisdom	2
Medium	migrate	2
Medium	prescribe	2
Hard	discredit	3
Hard	glimpse	1
Hard	lapse	1
Hard	salvage	2
Hard	utmost	2
Hard	susceptible	3
Hard	fringe	1

B. Words Used in the 2nd Experiment or 3rd Experiment

C. Consent Form before the Experiments

D. Debriefing after the Experiments

Table B.1 This word set was used as the "Word Set 1" in the 2nd experiment, and displayed in the learning session of "without the vibration, with the brackets" in the 3rd experiment.

Level	Words	The stress position
Easy	policeman	pol[i]ceman
Easy	performance	perf[o]rmance
Easy	volunteer	volunt[e]er
Easy	kilometer	kil[o]meter
Easy	community	comm[u]nity
Medium	advantage	adv[a]ntage
Medium	strategical	strat[e]gical
Medium	commercial	comm[e]rcial
Medium	discourage	disc[o]urage
Medium	decision	dec[i]sion
Medium	confidence	c[o]nfidence
Medium	insurance	ins[u]rance
Hard	oncologist	onc[o]logist
Hard	eventually	ev[e]ntually
Hard	irrelevant	irr[e]levant
Hard	scrupulously	scr[u]pulously
Hard	thermometer	th[e]rmometer
Hard	petroleum	petr[o]leum
Hard	condolence	cond[o]lence
Hard	authority	auth[o]rity

Table B.2 This word set was used as the "Word Set 2" in the 2nd experiment, and displayed in the learning session of "with the vibration, with the brackets" in the 3rd experiment.

Level	Words	The stress position
Easy	rhinoceros	rh[i]noceros
Easy	mountain	m[o]untain
Easy	vegetable	v[e]getable
Easy	environment	env[i]ronment
Easy	experience	exp[e]rience
Medium	exposure	exp[o]sure
Medium	suspicion	susp[i]cion
Medium	evidence	[e]vidence
Medium	discrepancy	discr[e]pancy
Medium	immediate	imm[e]diate
Medium	selection	sel[e]ction
Medium	innocence	[i]nnocence
Hard	hydrology	hydr[o]logy
Hard	foreclosure	forecl[o]sure
Hard	decorative	d[e]corative
Hard	cylindrical	cyl[i]ndrical
Hard	formidable	f[o]rmidable
Hard	construction	constr[u]ction
Hard	elaborate	el[a]borate
Hard	ordinance	[o]rdinance

Table B.3 This word set was displayed in the learning session of "with the vibration, without the brackets" in the 3rd experiment.

Level	Words	The stress position
Easy	interesting	[i]nteresting
Easy	impossible	imp[o]ssible
Easy	American	Am[e]rican
Easy	geography	ge[o]graphy
Easy	carefully	c[a]refully
Medium	exclusive	excl[u]sive
Medium	improvement	impr[o]vement
Medium	occasion	occ[a]sion
Medium	infection	inf[e]ction
Medium	miserable	m[i]serable
Medium	proportional	prop[o]rtional
Medium	provincial	pr[o]vincial
Hard	benevolence	ben[e]volence
Hard	impoverished	imp[o]verished
Hard	intrinsically	intr[i]nsically
Hard	protectionist	prot[e]ctionist
Hard	expatriate	exp[a]triate
Hard	infamous	[i]nfamous
Hard	exemplary	ex[e]mplary
Hard	conjunction	conj[u]nction

Table B.4 This word set was displayed in the learning session of "without the vibration, without the brackets" in the 3rd experiment.

Level	Words	The stress position
Easy	medicine	m[e]dicine
Easy	certainly	c[e]rtainly
Easy	chocolate	ch[o]colate
Easy	opinion	op[i]nion
Easy	vacation	vac[a]tion
Medium	rebellion	reb[e]llion
Medium	excessive	exc[e]ssive
Medium	sensation	sens[a]tion
Medium	accurately	[a]ccurately
Medium	mutually	m[u]tually
Medium	accompany	acc[o]mpany
Medium	unanimous	un[a]nimous
Hard	mandatory	m[a]ndatory
Hard	autonomous	aut[o]nomous
Hard	notorious	not[o]rious
Hard	privilege	pr[i]vilege
Hard	abdominal	abd[o]minal
Hard	circadian	circ[a]dian
Hard	copiously	c[o]piously
Hard	voracious	vor[a]cious

実験説明および同意書

この度は、私の実験に理解を示してくださりありがとうございます。以下、実験について説明させていただきます。

1. <u>個人情報管理</u>：これは慶應義塾大学メディアデザイン研究科（以降：KMD）に所属する学生が、卒業研究のために行うものです。なので、基本的に、実験者以外はあなた個人の結果や、実験をする上で知り得た個人情報をを見ることはありません (ただし、正当な権限、もしくは、正式な令状を持つ個人や機関からの情報開示請求、または、突発的緊急事態により実験者が個人情報を開示すべきであると判断した場合、はこの限りではありません)。
2. <u>学術的発表</u>について：全体の結果、または、個人の結果がKMDでの授業やその他の学会において使用される可能性はあります。しかし、氏名などの個人が特定される情報と紐づけての結果の公表は、KMD内外に関わらず、いかなる場においてもいたしません 。結果公表の必要がある場合は、必ず、ID番号などによって処理をした上で行います。
3. <u>実験中について</u>：当実験中に、心身の不調・異常・危険を感じた場合には、この同意書への記入に関わらず、いつでも実験を中断できます。またそれによる不利益は、一切ありません。
4. <u>実験概要</u>：時間は通常40分超、長くても1時間ほどです。モニターを見て、音を聞き、反応していただきます。また、人によっては、触覚刺激機器をつけさせていただく場合もあります。ただし、針を刺すなどの侵襲的手段は用いません。

以上のこと**すべて**に同意できるようでしたら、以下にサインをお願いします。
当実験に関して気になることがあれば、お気軽にお尋ねください。

<u>氏　名：　　　　　　　　　　　　　　　　</u>　<u>　　　　年　　月　　日</u>

実験結果のフィードバックを希望される場合、以下に連絡先をご記入下さい

<u>連絡先：　　　　　　　　　　　　　　　　</u>

実験者：堀松昇平 (GEIST所属)
連絡先：

指導教員：Prof. Kai Kunze
連絡先：

Figure C.1 All the participants put their signatures before the experiments. In case this becomes available to all the students of Keio University, my supervisor's and my contact addresses were deleted.

デブリーフィング

今回の実験は、言語認知に関わる実験でした。

Dupoux et al(1999)によると、日本人は英語などの西欧言語によく見られる子音の連続を、正しく聞き取れていないことが示唆されています。どういうことかというと、日本人は、こうした子音の連続の間に、無意識的に母音を補って音声を聞いてしまっています(Dupoux et al, 1999)。実はこれは言語学習に関わる大きな問題となりえます、。

言語獲得には自分が接した言葉から構成される、その言葉のモデルの模倣が大事だという説があります (大津, 2015)。これによるならば、言語への接し方の一つである、聞くということが正しくできていない以上、正しい言葉を身に付けることは不可能、ということになってしまいます。間違って聞こえているものから構成されるモデルは当然間違いを多く含んでいますから、それを足がかりにして学習者の中に構成される言語体系も間違いが多くなることが予想されるのです。

ここから、日本人は聞く段階から英語のカタカナ化が始まっており、それをモデルに会話をしてしまうから、必要以上に母音が入ってしまっていて、どこにアクセントが付いているのかよくわからない、平板化したカタカナ英語になってしまうという仮説が立てられます。

ところで、最近、触覚刺激を用いた言語認知の研究が進んでいます。触覚刺激によって、単語の意味が覚えやすくなったり(Jung et al 2016)、文全体のイントネーションがつかみやすくなった(Hwang & Cho 2012)という研究があります。

訪日外国人数が飛躍的に増えることが見込まれていたり、英語教育の低年齢化政策も進められていたりする昨今、英語教育が強く社会に求められている (または、求められるようになる) のは事実でしょう。そうした中で、正しく英語を聞き取れていないというのは、英語教育をかなり非効率にする可能性があるのです。

そこで今回は、学習者が取り組むことの多い単語の学習に的を絞り、触覚刺激が単語の聞き取り、特に、強勢(ストレス・アクセント) の位置の判断を助けることができるのかということを検証させていただきました。

ご協力ありがとうございました。

Figure D.1 This image is the document relating to the 3rd experiment, but all the participants were informed of the actual objection of the experiments after they finished.