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Pilot Study of Site-Specific Stimulation Presentation for the Development of a Stuttering Assistive Device

Takuma Yamamoto[1†] and Fumihide Tanaka[2]

[1]Intelligent and Mechanical Interaction Systems, University of Tsukuba, Ibaraki, Japan
(Tel: +81-90-5002-9604; E-mail: takuma.yamamoto@ftl.iit.tsukuba.ac.jp)
[2]Institute of Systems and Information Engineering, University of Tsukuba, Ibaraki, Japan
(Tel: +81-29-853-6175; E-mail: fumihide.tanaka@gmail.com)

Abstract: Stuttering is a speech disorder that makes fluent speech difficult. It is believed to be a worldwide phenomenon. There is currently no established treatment for people who stutter, so new methods of providing stuttering support are needed. Therefore, we focused on the distraction effect. In stuttering, the distraction effect refers to the phenomenon whereby symptoms are alleviated by diverting the speaker's attention away from speech. We believe that if this effect can be induced by presenting vibratory stimulation, it will be possible to develop a new stuttering support device. Additionally, previous studies have examined the effects of presenting vibration stimulation to people who stutter, but the effects of presenting vibration stimulation to multiple sites simultaneously have not been confirmed. Therefore, to develop a speech aid for people who stutter, this study created a device that delivers vibration stimulation while the person is speaking. The device was then used to deliver vibratory stimulation to one or more body parts while stuttering individuals read aloud to investigate its effect on core symptoms of stuttering.

Keywords: Stuttering, PWS, speech assist device, vibration stimulation

1. INTRODUCTION

Stuttering is a speech disorder that makes it difficult to speak fluently and affects approximately 5% of young children and 1% of adults worldwide[1-3]. The major symptoms include 'blocks', where speech is choked; 'prolongations', where sounds and words are prolonged; and 'repetitions', where the same sounds and words are repeated. These symptoms may be accompanied by secondary symptoms, such as facial expressions and movements. Although genetic factors, overactivity of the right brain, and other neurological factors have been suggested as possible causes of the disease, the underlying cause remains unknown and there is still no effective treatment for all stutterers[4]. Not only is stuttering reported to cause medical problems, it is also said to lead to social disadvantages such as bullying and teasing during school years, as well as affecting social status[5][6]. In fact, a US survey reported that people who stutter have an annual income that is $7,000 to $10,000 lower than that of people without a speech impediment[7]. Thus, stuttering is a speech disorder that is difficult to solve definitively, despite affecting people all over the world and having serious repercussions.

These challenges have recently prompted research into the use of vibrotactile feedback to support people who stutter. A previous study involving stutterers performing a speech task while receiving vibrations on their fingers, sternum or forehead showed that the frequency of stuttering decreased when a vibration stimulation was applied[8]. In addition, assistive devices with vibratory stimulation are reported to offer superior benefits in terms of reduced auditory interference, concealment and cost-effectiveness compared to conventional speech-lead devices[8]. However, most vibrotactile feedback devices to date have only stimulated a single site, and the effects of stimulating multiple sites simultaneously have rarely been verified. If it is shown that stimulating multiple sites simultaneously is more effective than stimulating a single site, this could lead to the development of more effective and practical stuttering assistive devices.

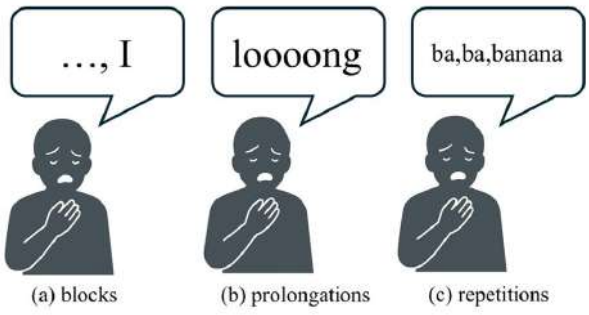


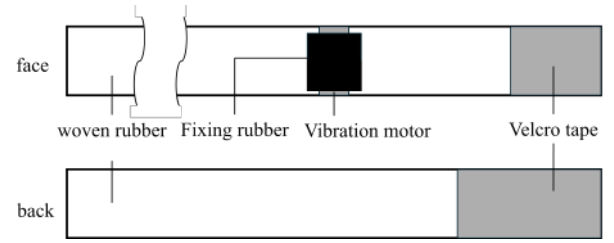
Fig. 1: Examples of core symptoms of stuttering

Therefore, in this study, we developed a device that provides vibration stimulation to multiple areas, such as the hands and forehead, simultaneously. We then investigated the effects of this device on stuttering frequency during oral reading. The aim of this investigation is to clarify the effectiveness of simultaneous multi-site stimulation and to contribute to the development of a new speech support device for people who stutter.

2. STIMULATION PRESENTING DEVICES

To investigate the effects of simultaneously stimulating multiple sites on stuttering, this study created a stimulator with rubber and a small vibration motor for each site. The locations at which the stimulation were pre-

† Takuma Yamamoto is the presenter of this paper.



(a) Outline and components of the developed device

(b) The wearing condition of the developed devices

Fig. 2: Appearance of the vibration motor when attached to the developed device.

sented were determined based on previous studies[8, 9]. These locations were the forehead, the wrists and the sole of the feet. Fig. 2 shows the outline of the developed device and its components, as well as how it is installed. The device is made of woven rubber and fixing rubber, as well as a small vibration motor and Velcro tape. It was designed to be lightweight and easy to install. The length can be adjusted with Velcro tape to accommodate differences in head circumference, wrist circumference and sole of the foot size when worn. The small vibration motors are positioned in the center of each device and designed to transmit vibration to the target area via the fixing rubber when mounted. When worn, the motor comes into contact with three parts of the body: the center of the forehead, the ulnar head, and the sole of the foot.

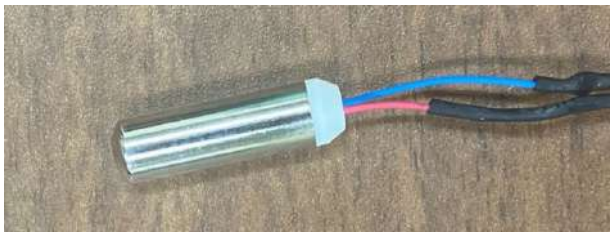
Fig. 3 shows the appearance of the small vibration motor and how it looks when attached to the stimulating vibration device. The vibration motor is PWM controlled by ESP32 WROVER and vibrates at approximately 200 Hz. The vibration motor is PWM controlled by ESP32 WROVER. The vibration stimulation is programmed to be presented for 20 seconds, followed by a 20-second pause. An emergency stop switch is attached to the control board and placed within reach of the wearer during the pilot study to stop operation.

3. PILOT STUDY

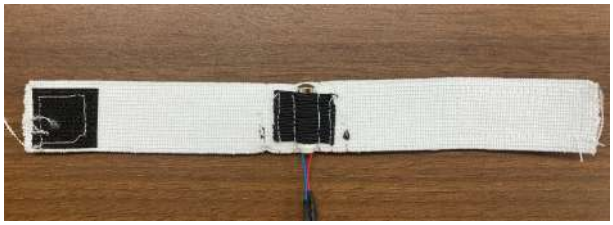
3.1. Object of Pilot Study

This pilot study aims to preliminarily verify the effects of the vibration stimulation produced by the developed device on the speech of people who stutter.

Particular attention was paid to the areas of the body where vibratory stimulation were presented, as well as to the effects of stimulating multiple areas simultaneously on speech.



(a) Appearance of vibration motor



(b) Appearance when attached to the developed device

Fig. 3: Appearance of the vibration motor when attached to the developed device.

3.2. Participants

The participants included one speaker, the first author of this paper who has stuttered since age six, and six evaluators, who were laboratory members. Three of the evaluators also served as observers. Three of the evaluators also served as observers. It has been reported that core symptoms of stuttering are less likely to occur during private speech in individuals with stuttering disorders[10]. Therefore, to prevent the speaker from viewing the oral reading task as a soliloquy, three evaluators were assigned as observers. They were seated within the speaker's field of vision during the speech task, where they observed and listened to the speaker.

3.3. Methods

The following procedure was followed for this pilot study. The procedure for the speaker is shown below.

1. Complete the pre-speech questionnaire.
2. Attachment of device
3. Complete a one-minute read-aloud task, which will be recorded.
4. Read the questionnaire aloud and then answer it.
5. 5-minute break
6. Change the condition and retry. Return to step 3 if applicable.
7. Completed pilot study questionnaire.

As an oral reading task, the students were asked to read a passage from a Japanese novel aloud for one minute. The eight vibration stimulation patterns shown in Table. 1 were presented, one for each speech task. The order of presentation was randomised. Note that different sentences were used for each assignment to avoid becoming accustomed to identical ones. The procedure for the evaluator is shown below.

1. Description of the core symptoms of stuttering (blocks, elongated and continuous stuttering) in writing.
2. Watch videos of speakers reading aloud and count the number of core symptoms of stuttering.

Table 1: Vibration patterns presented in the experiment

Condition	Vibration Pattern
Control	No stimulation (control condition)
1	Forehead only
2	Wrist only
3	Sole of the foot only
4	Forehead + Wrist
5	Forehead + Sole of the foot
6	Wrist + Sole of the foot
7	All

3. Complete the questionnaire evaluating the oral reading assignment.
4. Change the condition and re-evaluate. Return to step 2 if applicable.
5. Completed pilot study questionnaire.

In addition to the evaluator's procedures, it was the observer's responsibility to sit in the speaker's field of view during the speech task and observe it. This pilot study involved three sets of eight vibration stimulation patterns, with one set conducted each day. The Speaker Questionnaire asks about the use of the device and the perceived effectiveness of the device, while the Evaluator Questionnaire asks about the number of core symptoms of stuttering and the speaker's level of tension from the evaluator's perspective.

We evaluated the developed instrument by calculating and comparing the number of core symptoms of stuttering per 100 phonemes. We obtained the average number of core symptoms of stuttering through the questionnaire and counted the number of phonemes in the read aloud sentences.

The level of tension was evaluated using a seven-point Likert scale. Higher numbers on this scale indicated higher tension.

4. RESULTS

The results of the pilot study are shown below.

Table. 2 and Table. 3 suggest that raters may have rated participants as more tense when they exhibited more stuttering core symptoms, particularly in the no-stimulus condition of the first pilot study, when the number of core symptoms of stuttering and level of tension were lowest.

In the first pilot study, the lowest number of core symptoms of stuttering per 100 phonemes occurred in the no-stimulus condition (0.624 ± 1.235)(Mean ± SD), while the highest number occurred when vibration was presented to the wrist and sole of the foot (1.617 ± 1.359). In the second pilot study, the fewest core symptoms of stuttering per 100 phonemes occurred in the no stimulus condition (1.282 ± 0.677), while the most occurred when vibration was presented only to the wrist (2.743 ± 1.385). In the third pilot study, the fewest core symptoms of stuttering per 100 phonemes were found in the forehead and wrist vibration condition (0.456 ± 0.569), while the most were found in the no vibration condition

Table 2: Mean and standard deviation of the number of core symptoms of stuttering for each condition

Condition	Trial 1		Trial 2		Trial 3	
	Mean	SD	Mean	SD	Mean	SD
No stimulation	0.624	1.235	1.282	0.677	2.299	2.518
Forehead	0.838	0.790	1.948	1.523	1.627	1.297
Wrist	1.617	1.359	2.743	1.385	0.935	0.763
Sole	1.461	1.379	2.729	1.590	1.114	0.702
Forehead + Wrist	1.406	0.690	1.585	1.707	0.456	0.569
Forehead + Sole	0.717	0.621	1.884	1.348	1.886	1.255
Wrist + Sole	1.489	0.509	2.703	2.317	1.164	1.660
All	1.402	0.530	2.226	0.938	0.875	0.412

Table 3: Mean and standard deviation of the level of tension for each condition

Condition	Trial 1		Trial 2		Trial 3	
	Mean	SD	Mean	SD	Mean	SD
No stimulation	1.667	1.826	4.167	3.851	4.833	4.340
Forehead	3.500	3.674	4.500	5.050	4.000	4.000
Wrist	4.500	4.183	4.333	4.619	3.333	4.163
Sole	4.500	4.183	4.667	4.619	2.833	2.972
Forehead + Wrist	4.000	4.000	4.000	4.690	2.000	2.000
Forehead + Sole	2.667	3.651	4.500	3.674	4.333	3.916
Wrist + Sole	4.667	4.397	5.333	3.916	3.167	3.851
All	3.167	4.340	4.333	4.163	2.833	3.291

(2.299 ± 2.518). The sole of the foot and forehead vibration condition received the most attention in the speaker questionnaire. Regarding the image of stuttering in the evaluator questionnaire, respondents commented that it is a symptom of getting stuck on words, and that stuttering is strongly associated with continuous speech impediments. On the other hand, some commented that identifying the core symptoms of stuttering was difficult, and they were unsure whether to judge based on speech or facial expressions.

5. DISCUSSION AND FUTURE WORK

This pilot study did not confirm a significant effect of simultaneous vibration stimulation on stuttering. We believe this is because the completeness of the equipment, control of the experimental environment, questionnaire content, sample size, etc. were not sufficient. Additionally, since previous studies have shown that presenting vibrations increases speech fluency[8, 9, 11], we believe that using appropriate vibration stimulation could decrease core symptoms of stuttering in people who stutter. Furthermore, Table. 2 and Table. 3 suggest that evaluators may have perceived participants as more tense when they exhibited more core symptoms of stuttering. Specifically, in the no-stimulus condition of the first pilot test, the average values for the number of core symptoms of stuttering and the level of tension were lowest. Based on the findings obtained in this study, future prospects are as follows.

5.1. Improve Evaluation Methods

In this pilot study, we received many comments regarding the difficulty of evaluation. The reason is that none of the evaluators are speech-language pathologists

or other specialists. Therefore, it would be effective to present a simplified evaluation method for assessing core symptoms of stuttering based on expert criteria. This would allow for certain evaluations to be performed by non-experts and by more than one person.

It also highlights the need for a survey that can clearly identify which parts of the video were rated as stuttering symptoms. Therefore, we propose a system that allows users to record the relevant part by pressing a button during the evaluation. Using multiple buttons allows for a step-by-step evaluation of severity and a more detailed analysis. We plan to simplify the evaluation process in the future.

5.2. Improved Text Selection Process

This pilot study involved performing a speech task using a Japanese novel. One of the problems was that several sentences contained kanji that could not be read. While trying to read them, they appeared difficult. Therefore, in the future, we would like to solve this problem by using simple books, such as elementary school textbooks.

5.3. Change of Speech Assignment

This pilot study employed reading aloud as the speech task. However, we felt that it was difficult to quantitatively evaluate the read-aloud task because the difficulty of the text could affect stuttering. Additionally, the cognitive load was low since participants were only reading the written text. Using a speech task instead of a read-aloud task enables speech that requires a high level of cognitive thinking and speaking. Furthermore, unlike the oral reading task, the speech task enables participants to speak without looking at the document. This makes the speech task more partner-oriented and may accentuate core symptoms of stuttering. In the future, we plan to adjust the conditions of the speech task for greater control.

5.4. Improved Quality of Vibration Stimulation

This pilot study involved attaching a vibration presentation device to each body part and presenting vibration stimulation during a speech task. In terms of sensation, stimulation of the forehead and soles of the feet was noticed, but not as much stimulation of the wrists. Although the present results are consistent with previous studies, it should be noted that the wrist is one of the easiest places to wear the device. If the same level of attention dispersal effect can be achieved on the wrist as on the foot or forehead, it could greatly contribute to developing a speech support device that uses vibration stimulation and can be worn on the wrist. Therefore, we plan to develop a new method for transmitting vibration stimulation from the vibration motor.

6. CONCLUSION

In this study, a vibration stimulation presentation device was attached to each body part of a person who stutters while speaking. The effects of presenting vibration stimulation on the number of core stuttering symptoms and the differences in effects at each site and with simultaneous stimulation were investigated through pilot studies. The results did not confirm that stimulating multiple locations simultaneously reduced core symptoms of stuttering. We plan to use the results of this study to improve the system's equipment and evaluation methods.

7. ACKNOWLEDGEMENT

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