Comparison of Vibrotactile Display and Pseudo-mastication Sound Display on Food Texture Perception

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Introduction

Eating is an experience that involves all five senses

https://free-materials.com/tag/

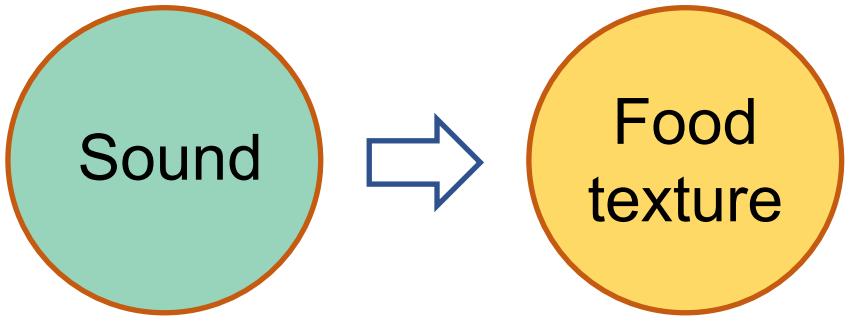
Flavor	Aroma	Food texture	Sound	Visual
taste	smell	touch	hearing	eyesight

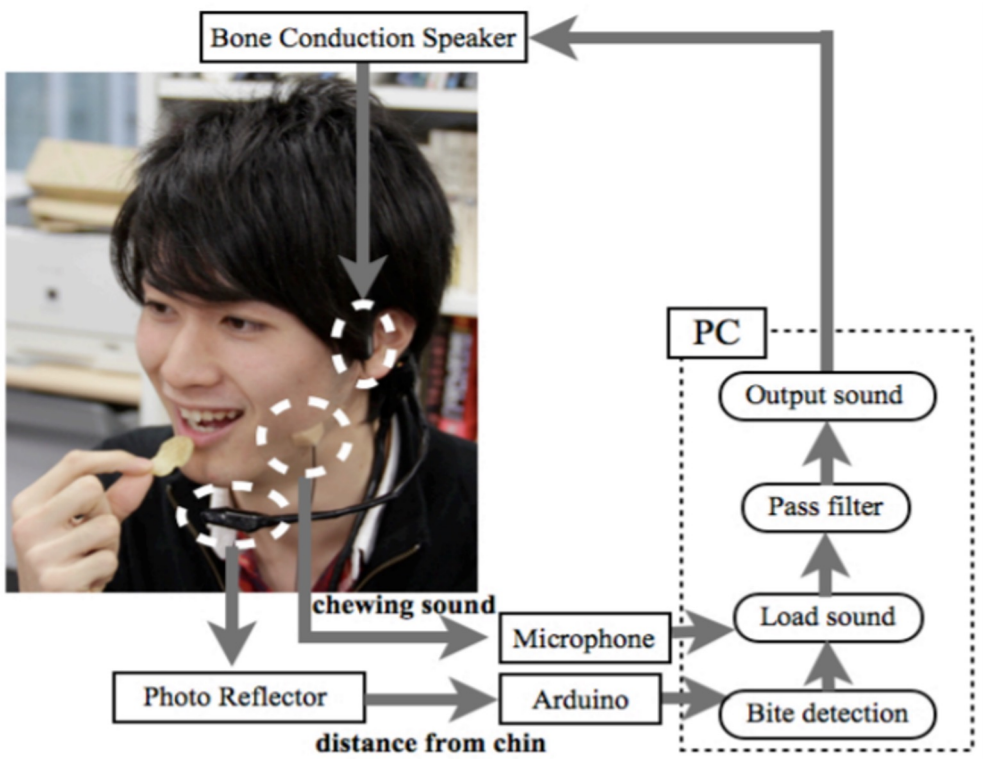
Introduction

Cross-modal : A phenomenon in which separate sensory information interacts with each other to affect the perception of certain sensory information

Applied high-pass filter to the mastication sound

→ Texture of potato chips was perceived as crispier.





Chewing JOCKEY [1]

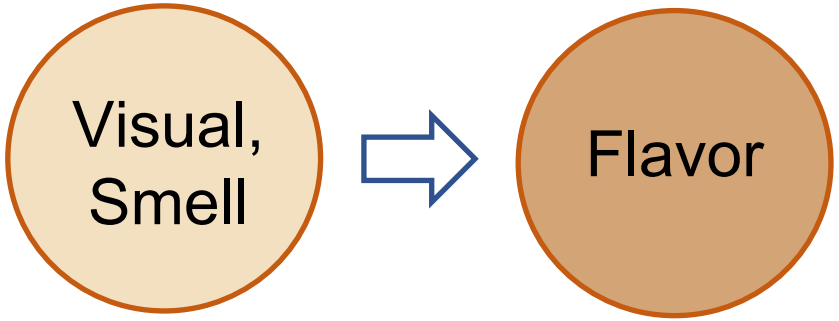
[1] Naoya Koizumi, Hidekazu Tanaka, Yuji Uema, and Masahiko Inami, "Chewing jockey: augmented food texture by using sound based on the cross-modal effect." *Proceedings of the 8th international conference on advances in computer entertainment technology*. 2011. pp1-4

Introduction

Cross-modal : A phenomenon in which separate sensory information interacts with each other to affect the perception of certain sensory information

Manipulated visual and smell information

→ Participants tasted chocolate cookies even though they ate butter cookies



MetaCookie+ [2]

[2] Narumi, Takuji, et al. "Augmented reality flavors: gustatory display based on edible marker and cross-modal interaction." *Proceedings of the SIGCHI conference on human factors in computing systems*. 2011. pp. 93-102

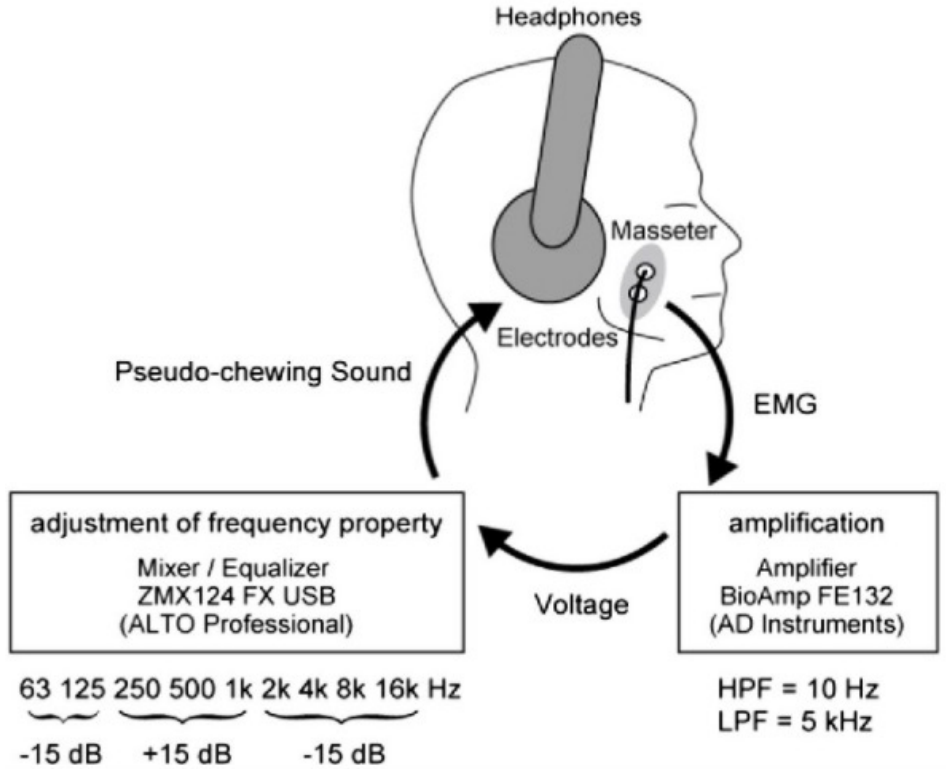
Related work

Pseudo-mastication sound generated from Electromyogram (EMG) during mastication

⇩

Increased the perception of hardness, comfort and satisfaction of soft food for elderly

However, few studies used vibrotactile stimuli on food texture



Presenting pseudo-mastication sound generated from EMG [3]

[3] Hiroshi Endo, Shuichi Ino, and Waka Fujisaki. "The effect of a crunchy pseudo-chewing sound on perceived texture of softened foods." *Physiology & behavior* 167 (2016): pp324-331.

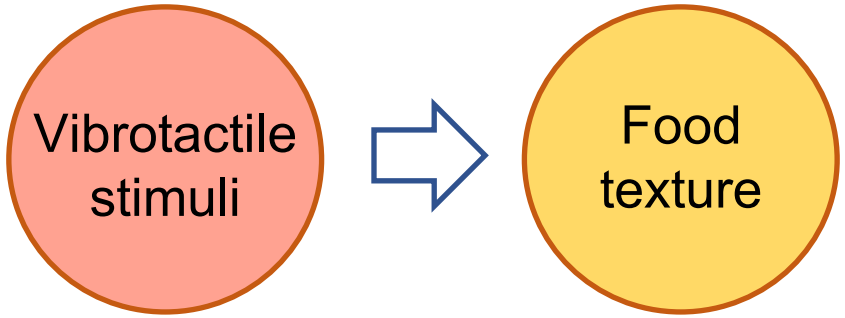
Our research

Purpose

Investigation of the effect of vibrotactile stimuli to the whole body on the perception of food texture during mastication

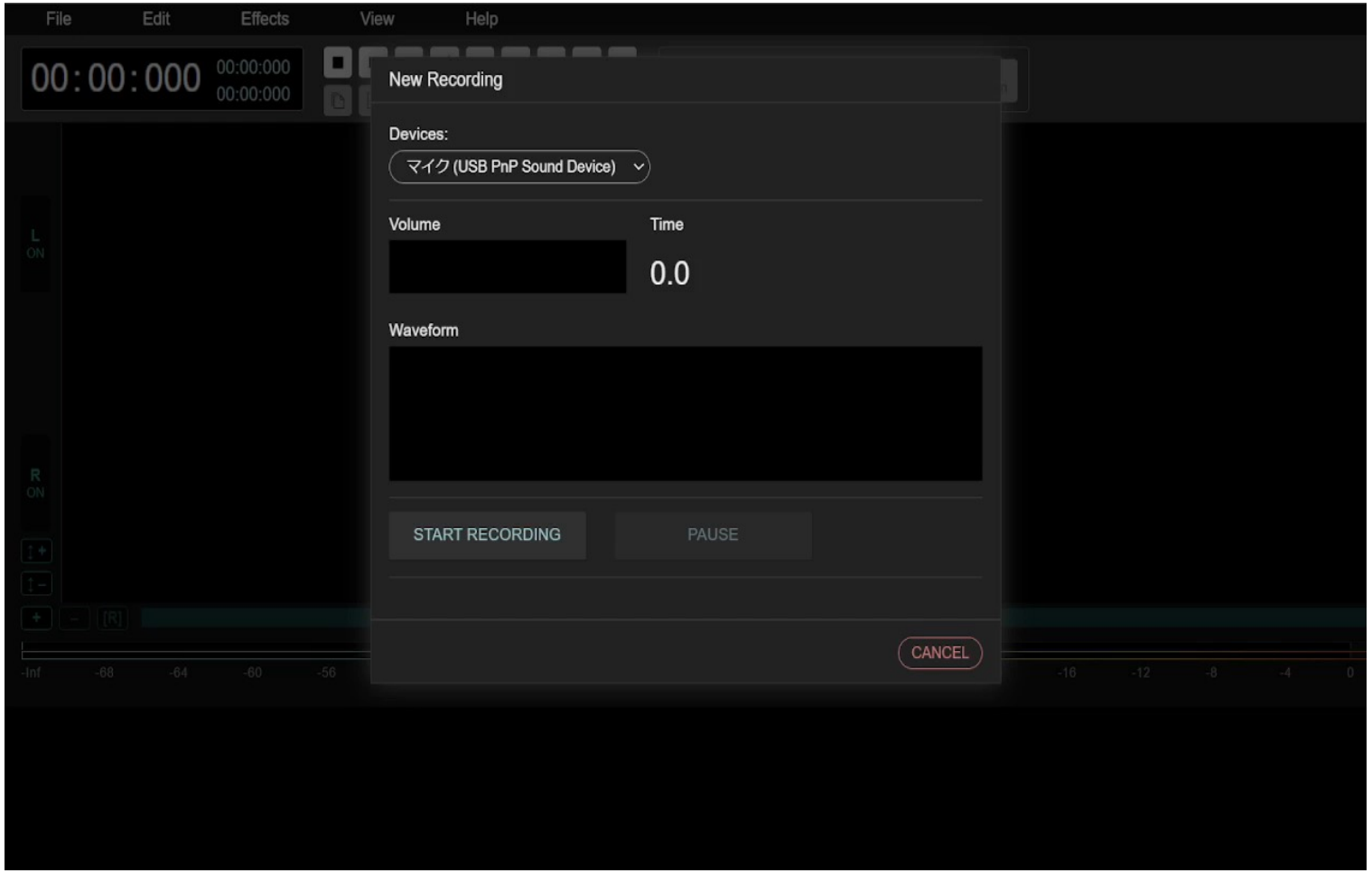
Our method

- Generation of vibrotactile stimuli by employing myoelectric potentials or mastication sound during mastication
- Presenting vibrotactile stimuli to the whole body



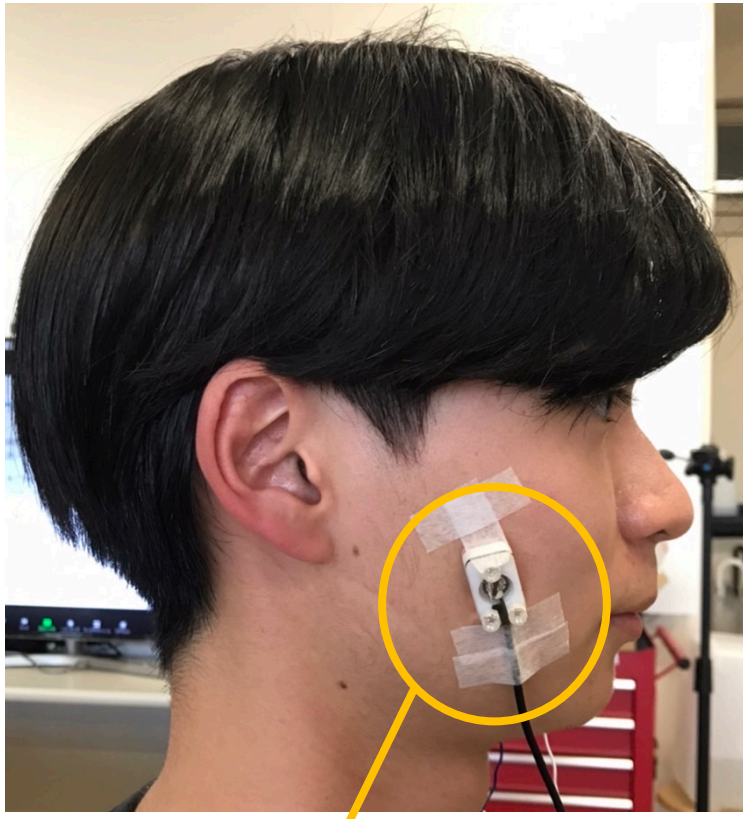
Myoelectric Potential

Electrode

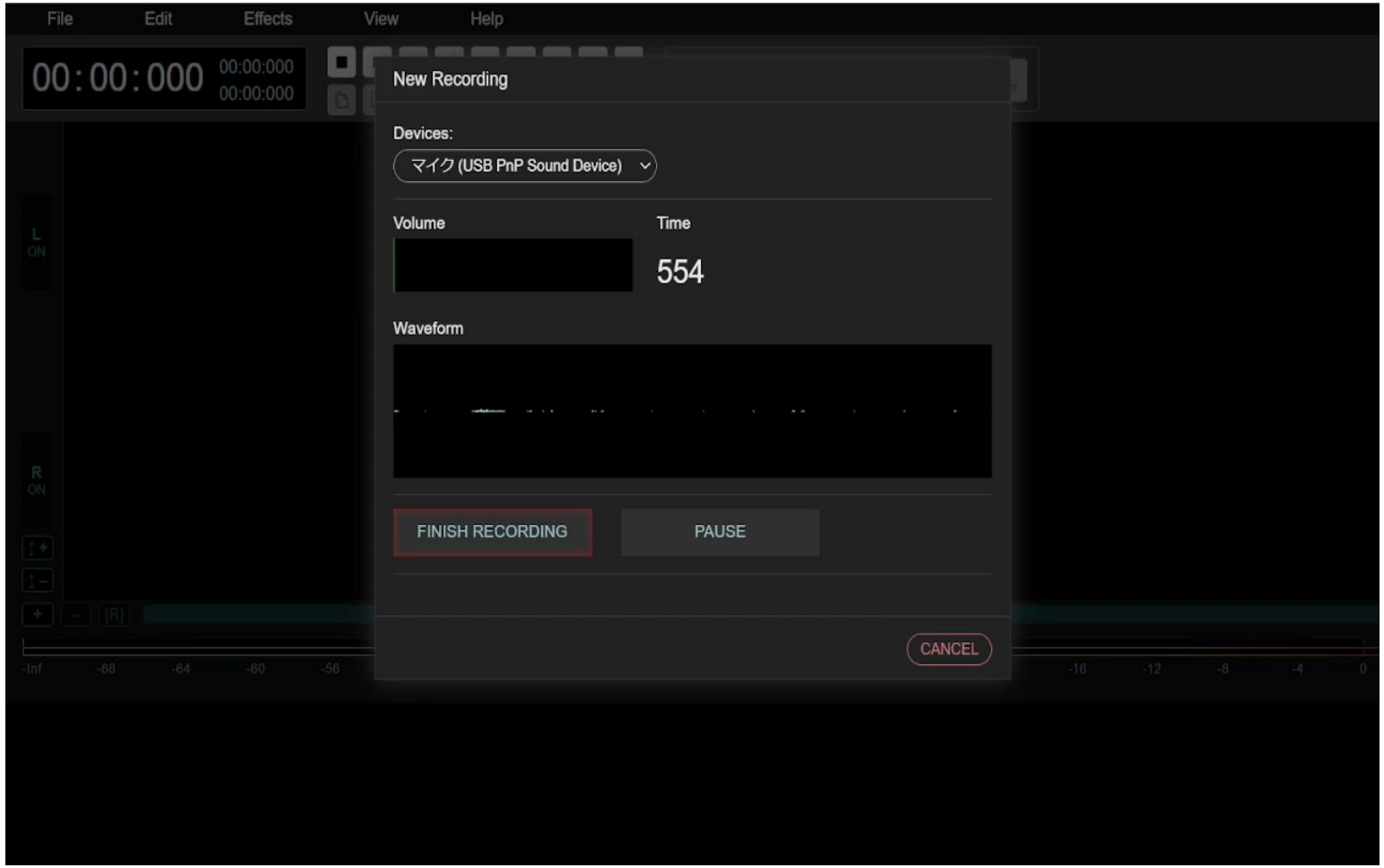


Audiomass

Mastication sound



Condenser Microphone



Audiomass

Method

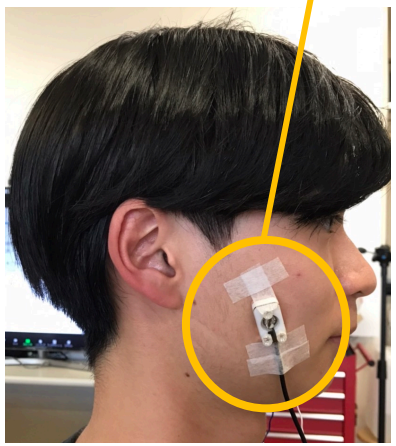
Myoelectric potential or Mastication sound

Input signal

Amplify

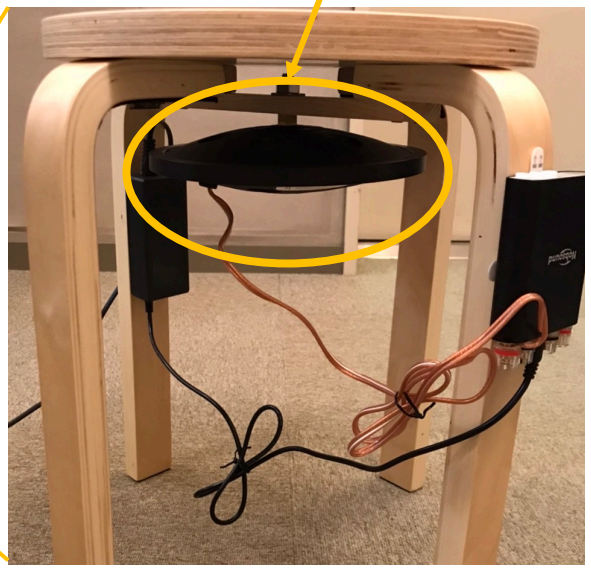
Amplified signal

Vibrotactile stimuli



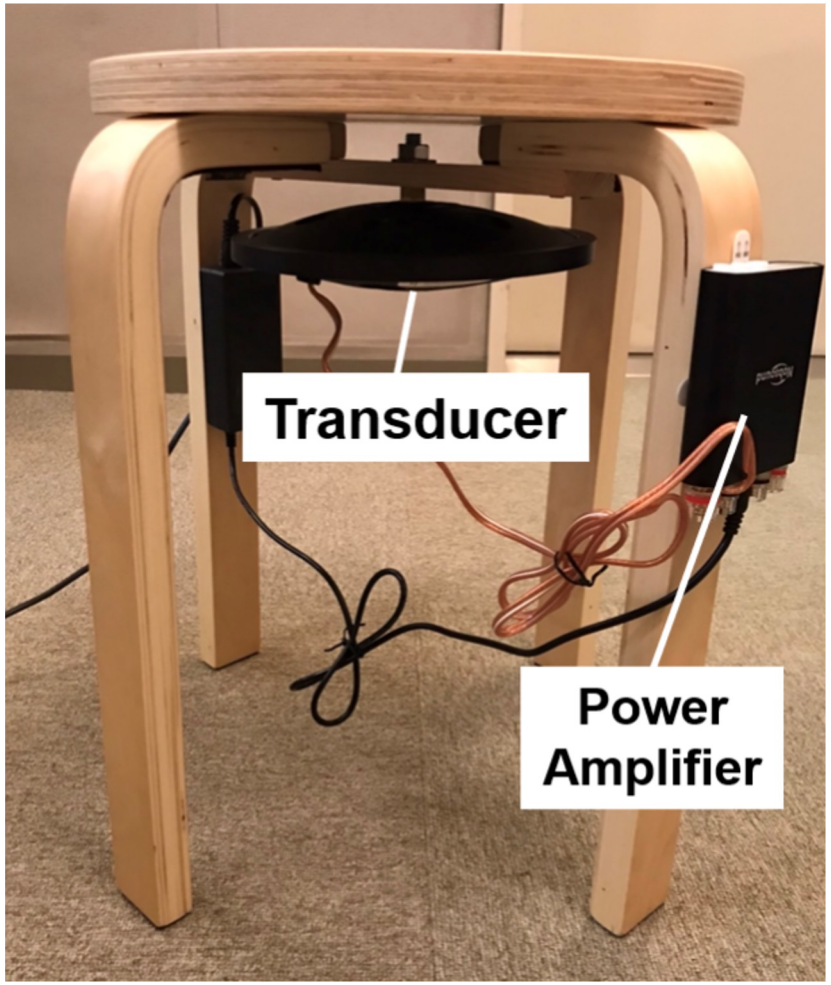
Condenser microphone

Electrode



Vibrotactile stimuli to the whole body

Vibration device

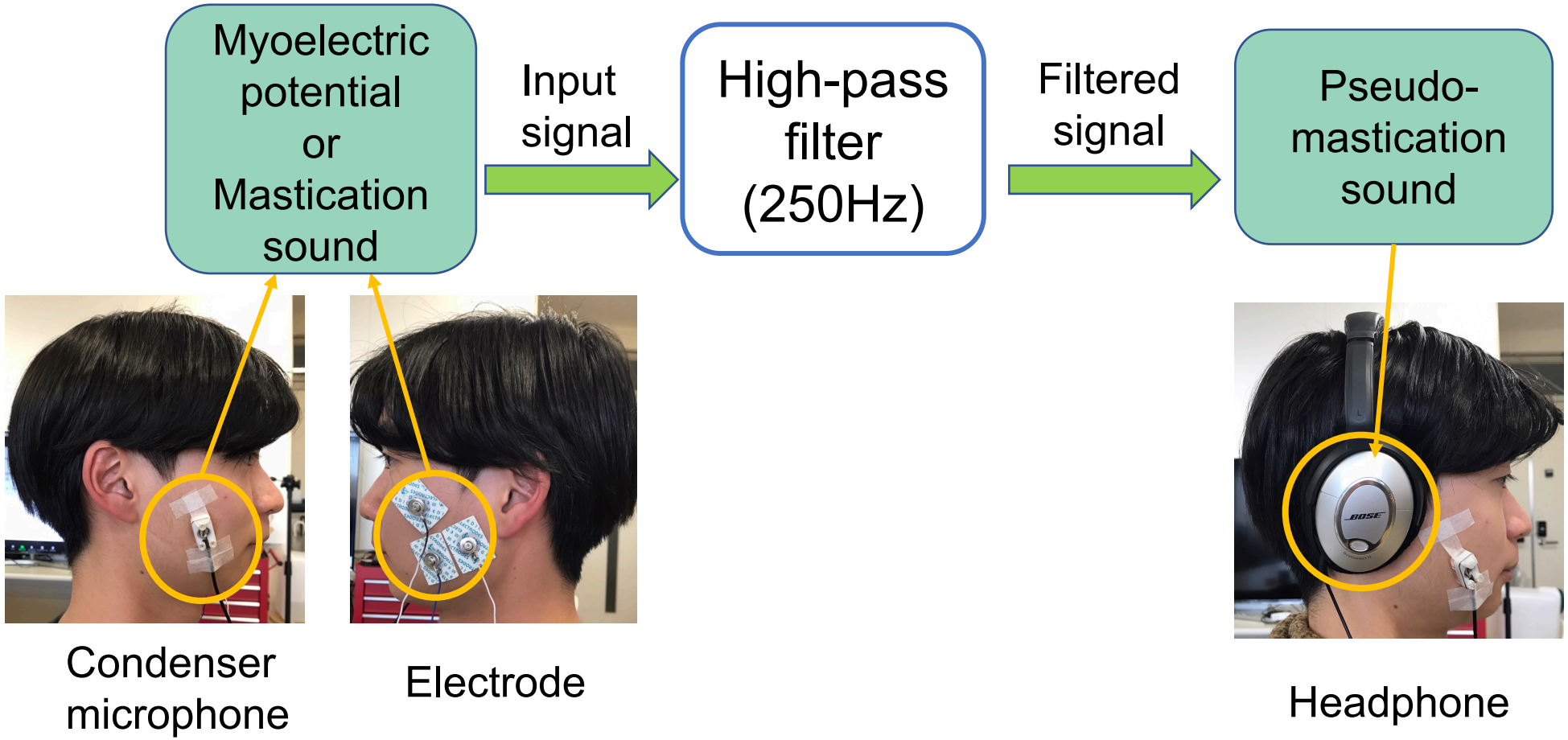


Vibration device

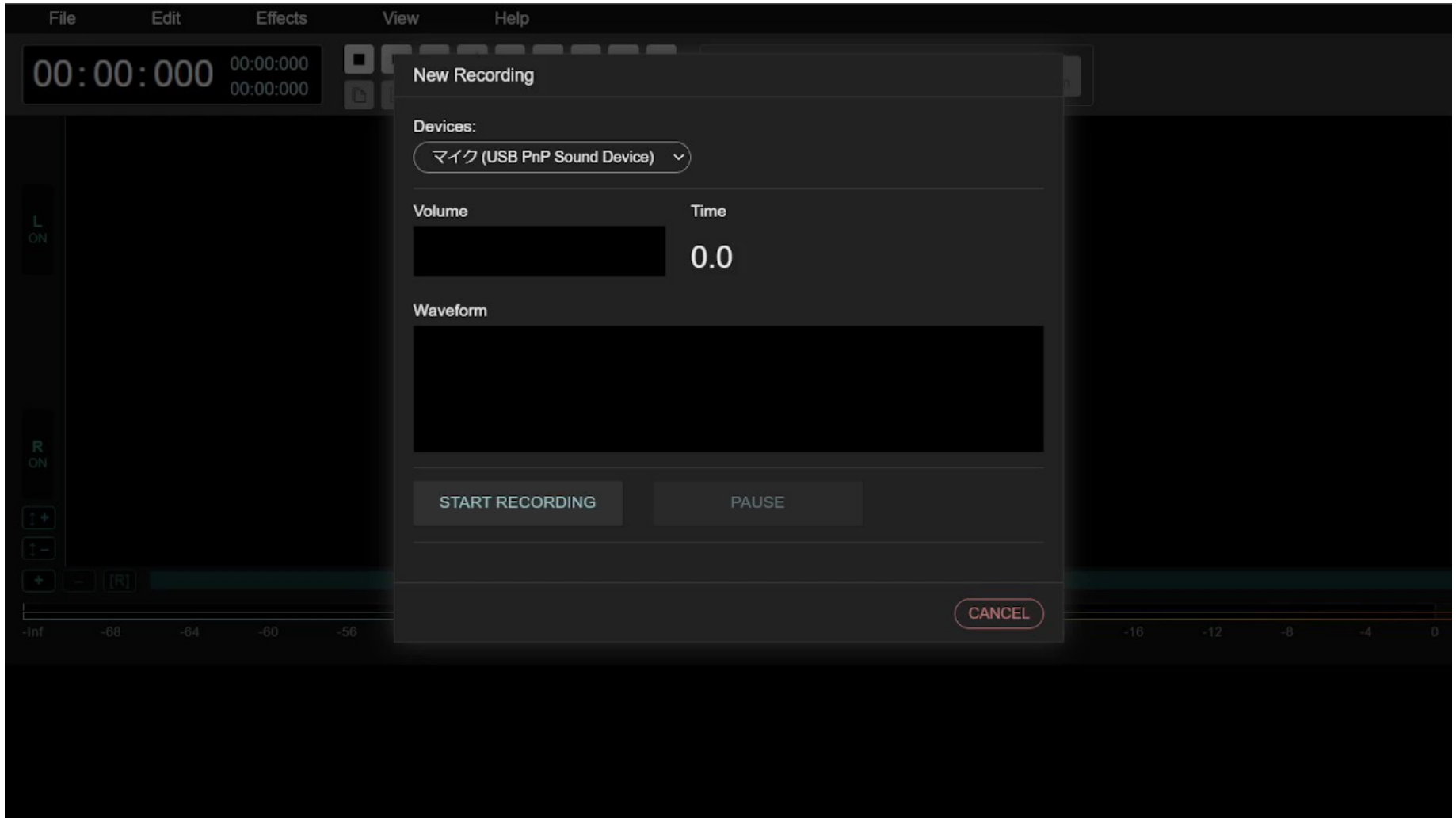
Participant sitting on the vibrotactile chair

Pseudo-mastication sound

Refered to related work



Pseudo-mastication sound applied filter



Experiment

Purpose

To investigate the effect of vibrotactile stimuli on food texture perception

Experimental conditions

Condition	Input	Output
A	None	None
B	Mastication sound	Vibotactile stimuli
C	Mastication sound	Pseudo-mastication sound
D	Myoelectric potential	Vibrotactile stimuli
E	Myoelectric potential	Pseudo-mastication sound

Rice cracker used in the experiment

Experiment

12 participants (9 males and 3 females,18 to 22 ages)

1. Participants were seated at the chair
2. Attached electrodes and condenser microphone to the masseter muscle
3. Participants were asked to masticate food
4. Evaluate nine items related to food texture
5. Follow the same procedure for conditions B to E

Participant masticating food

Adjective pairs of questionnaires

Evaluation items with 7-point likert scale

Q1 Soft – Hard
Q2 Not crispy – Crispy
Q3 Sparse – Dense
Q4 Thin – Thick
Q5 Not chewy – Chewy
Q6 Unnatural – Natural
Q7 Stale – Fresh
Q8 Uncomfort – Comfort
Q9 Not sticky – Sticky

Participant masticating food

Result

Wilcoxon signed rank test for condition A and other conditions (p-value was 5%)

Evaluation items	Condition B	Condition C	Condition D	Condition E
Q1 Soft - Hard	0.019	0.257	0.059	0.317
Q2 Not crispy - Crispy	0.666	0.739	0.006	0.414
Q3 Sparse - Dense	0.096	0.005	0.305	0.085
Q4 Thin - Thick	0.180	0.034	0.157	0.701
Q5 Not chewy - Chewy	0.279	0.234	0.008	0.527
Q6 Unnatural - Natural	0.414	0.031	0.202	0.003
Q7 Stale - Fresh	0.041	0.516	0.071	0.581
Q8 Uncomfort - Comfort	0.705	0.161	0.792	0.019
Q9 Not sticky - Sticky	0.654	0.654	0.157	0.180

Result

Vibrotactile display

Evaluation items	Condition B	Condition C	Condition D	Condition E
Q1 Soft - Hard	0.019	0.257	0.059	0.317
Q2 Not crispy - Crispy	0.666	0.739	0.006	0.414
Q3 Sparse - Dense	0.096	0.005	0.305	0.085
Q4 Thin - Thick	0.180	0.034	0.157	0.701
Q5 Not chewy - Chewy	0.279	0.234	0.008	0.527
Q6 Unnatural - Natural	0.414	0.031	0.202	0.003
Q7 Stale - Fresh	0.041	0.516	0.071	0.581
Q8 Uncomfort - Comfort	0.705	0.161	0.792	0.019
Q9 Not sticky - Sticky	0.654	0.654	0.157	0.180

Participants perceived the texture as harder, crispier, chewier and fresher

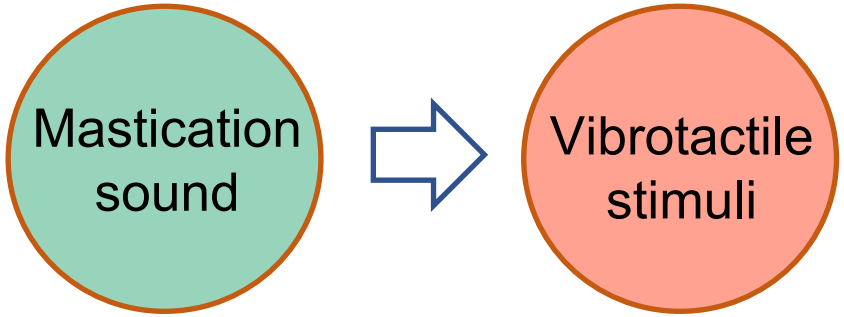
Result

Evaluation items	Condition B	Condition C (Pseudo-mastication sound display)	Condition D	Condition E (Pseudo-mastication sound display)
Q1 Soft - Hard	0.019	0.257	0.059	0.317
Q2 Not crispy - Crispy	0.666	0.739	0.006	0.414
Q3 Sparse - Dense	0.096	0.005	0.305	0.085
Q4 Thin - Thick	0.180	0.034	0.157	0.701
Q5 Not chewy - Chewy	0.279	0.234	0.008	0.527
Q6 Unnatural - Natural	0.414	0.031	0.202	0.003
Q7 Stale - Fresh	0.041	0.516	0.071	0.581
Q8 Uncomfort - Comfort	0.705	0.161	0.792	0.019
Q9 Not sticky - Sticky	0.654	0.654	0.157	0.180

Participants perceived the texture as denser, thicker, unnatural, and uncomfortable

Discussion: Vibrotactile stimuli

Condition B

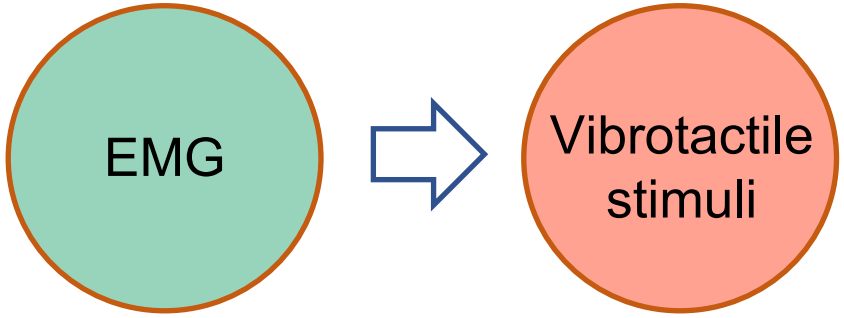


Evaluation items	Condition B
Q1 Soft - Hard	0.019
Q7 Stale - Fresh	0.041

Comments

- I felt the food to be hard more than usual.
- I felt vibration from the chair as if something hit the bottom of the chair.

Condition D



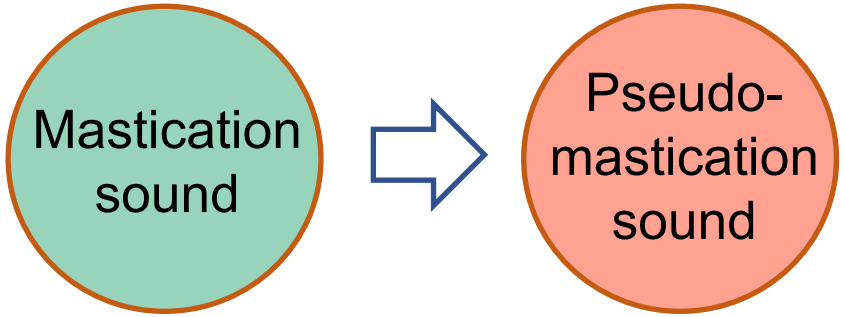
Evaluation items	Condition D
Q2 Not crispy - Crispy	0.006
Q5 Not chewy - Chewy	0.008

Comments

- I was like eating food with my whole body.
- I felt the enhanced chewiness of rice cracker.

Discussion: Pseudo-mastication sound

Condition C

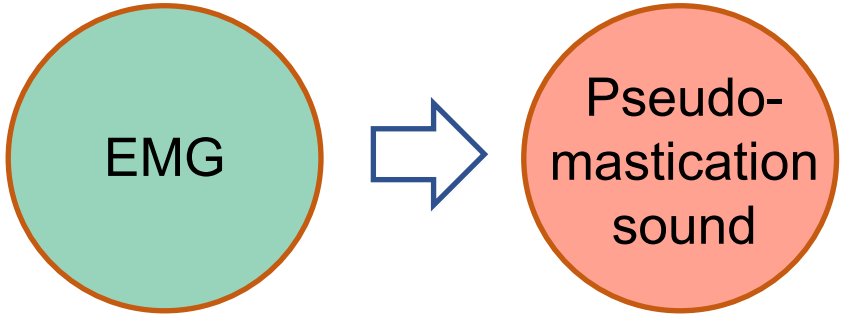


Evaluation items	Condition C
Q3 Sparse - Dense	0.005
Q4 Thin - Thick	0.034
Q6 Unnatural - Natural	0.031

Comments

- I heard crispy sound.
- I felt the volume of rice cracker had increased.

Condition E



Evaluation items	Condition E
Q6 Unnatural - Natural	0.003
Q8 Uncomfort - Comfort	0.019

Comments

- The sound was uncomfortable.
- It sounded like ASMR (Autonomous Sensory Meridian Response).

Discussion: Affected attributes

Vibrotactile stimuli

- Hardness
- Crispness
- Chewiness
- Freshness

No commonality

Pseudo-mastication sound

- Dense
- Thickness
- Naturalness of sound
- Uncomfort

Low-frequency component was a significant factor

High-frequency component was a significant factor

Different frequency bands in vibrotactile information and auditory information could have led to difference in affected attributes

Conclusion

Vibrotactile stimuli ⇨ Food texture

Purpose

Investigation of the effect of vibrotactile stimuli to the whole body on the perception of food texture during mastication

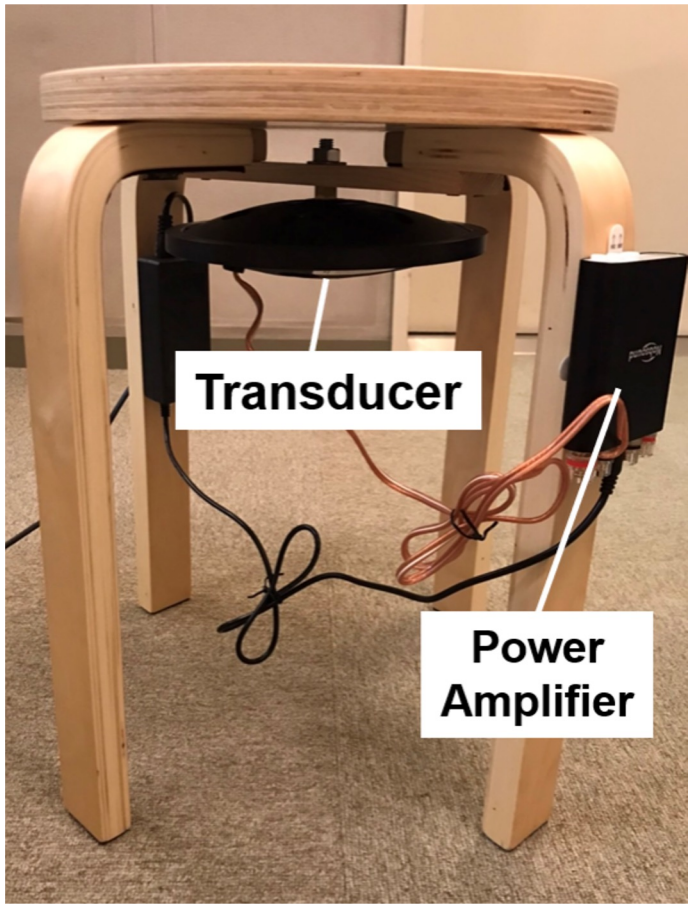
Method

Generation of vibrotactile stimuli by employing myoelectric potential or mastication sound as input signal

Result

Our method affected the perception of rice cracker texture

- Hardness, Crispness, Chewiness, Freshness



Future work

- Investigation of the effect of presenting both vibrotactile and auditory information on the perception of food texture
- Experiments on other food items
- Use of bone-conduction microphone
- Many participants commented that they enjoyed eating with the vibrotactile information presented

→ Proposal for a system that improves the eating experience