Change in the Amount Poured as a Result of Vibration When Pouring a Liquid

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Abstract Visual and tactile stimulation is known to affect the experience of eating and drinking. In this study, we focused on the vibration of a Japanese sake bottle when used to pour liquid. We manufactured a device that can be attached to the neck of any plastic bottle and investigated how beverage consumption was affected by the vibration. We found that presentation of the vibration affected the amount of poured beverage when visual and sound cues were masked.

Keywords Pouring water · Tactile display · Drink consumption · Vibration · Human food interaction

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1 Introduction

Serving containers are known to affect the experience of eating and drinking, as well as the appearance and flavor of food and beverages. Wanshink and Ittersum [1] showed that food consumption increased when a larger spoon or dish was used to serve food. Furthermore, consumption of beverages is affected by the size and shape of the cup used to serve them. Sakurai et al. [2] and Suzuki et al. [3] changed the appearance of food and beverage containers and regulated the consumption of food and drink using augmented reality technology.

In this study, we focused on the vibration of liquid being poured from a Japanese sake bottle as an audio-haptic rendition of the liquid. Sake bottles are known for their unique "glug" sound and vibration. We believe that these sounds and vibrations affect the subjective impressions of the amount of liquid in the bottle. Thus, we developed a device that can reproduce this vibration [4]. In this study, we manufactured a vibration device that can be attached to the neck of any plastic bottle and investigated how beverage consumption was affected by the subsequent vibrations.

2 An Attachment-Type Device

Figure 1 shows our device, which can be attached to the neck of any plastic bottle. The device has an accelerometer (KXM52-1050, Kionix) and a vibrator (Haptuator Mark II, Tactile Labs Inc.). We used the cap of the plastic bottle as an attachment point for the device. The device does not obstruct the movements required to pour liquid from the bottle.

In our previous report, we reproduced the wave of the vibration using the following model, which comprised two decaying sinusoidal waves with different frequencies [4]:

Fig. 1 An attachment-type device

$$Q(\theta, t) \fallingdotseq \sum_{n=1}^{2} A(\theta)_n \exp(-B(\theta)_n t) \sin(2\pi f(\theta)_n t) \quad (1)$$

where A_n is the wave amplitude, B_n is the attenuation coefficient, f_n is the frequency of the sinusoidal wave, and t is the time period of one wave. Typically, f_1 was around 250 Hz, and f_2 was around 40 Hz.

We used this model to describe the motion of the device. When a user tipped the plastic bottle, the device presented a vibration according to the angle of the bottle.

3 Experiment

We conducted an experiment to see whether the added vibration had an effect on the amount of liquid poured.

3.1 Experimental Environment and Procedure

We recruited four participants (two males and two females, 22–24 years of age). The participants were blindfolded and any sound cues were masked by white noise that was presented through headphones.

Figure 2 shows experimental setting. We prepared 500 ml of water in a plastic bottle with the device attached. There were two conditions: with vibration and without vibration. The participants were asked to pour a designated amount of water, 100, 200, 300 ml, or 400 ml, into a 500 ml cup. For each trial, the participants were shown a marker inside the cup that indicated the level of the designated amount of water. They were then blindfolded and asked to pour the water from the

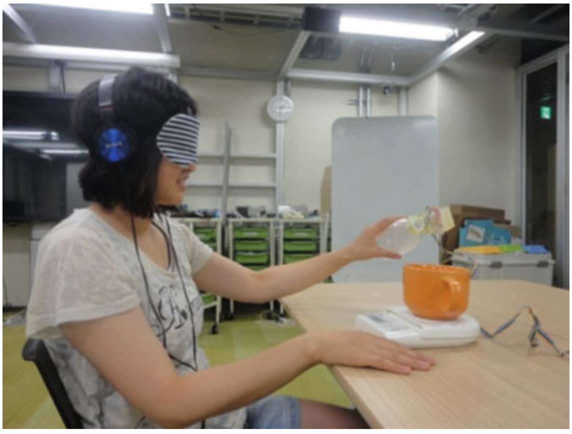

Fig. 2 Experimental setting

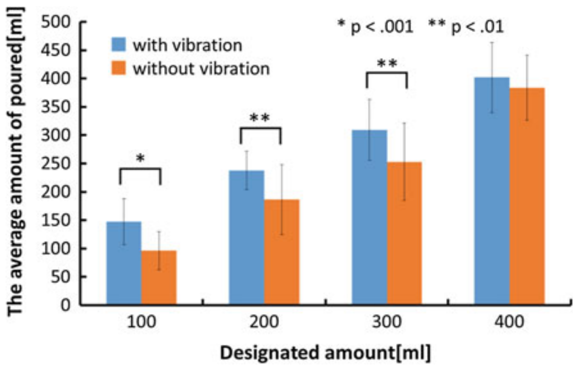

Fig. 3 Average amount of poured

bottle. After they felt that they had poured the designated amount, we measured the amount using an electric scale. There were ten trials for each amount of liquid, 40 trials in total for each participant.

3.2 Results and Discussion

Figure 3 illustrates the average amount of liquid poured and the standard errors in each experimental condition. The horizontal axis represents the designated amount, and the vertical axis represents the average amount of poured water. The participants poured 35 % less in the trials with vibration compared with the trials without vibration at 100 ml, 22 % at 200 ml, 18 % at 300 ml, and 5 % at 400 ml.

We conducted a t-test that revealed significant differences between the pouring conditions at 100 ml ($p = 0.0001$), 200 ml ($p = 0.003$), and 300 ml ($p = 0.006$), although we found no significant differences between the conditions for the 400 ml trials ($p = 0.34$).

These results suggest that the presentation of the vibration affected the amount of liquid poured. Additionally, the effect of the device was more powerful when the designated amount of water was smaller. It is possible that when the amount of liquid to be poured was small, the participants became more conscious of their movements and were thus more affected by the vibration.

4 Conclusions

In this study, we focused on the vibration of liquid being poured from a Japanese sake bottle as an audio-haptic rendition of the liquid. We manufactured a device that reproduced the vibration created by pouring a liquid. This device can be attached to the neck of any plastic bottle. We investigated how pouring of liquids, which is a precursor to beverage consumption, would be affected by the vibration and found that vibration significantly reduced the amount of liquid poured when visual and sound cues were masked.

Future research could test the effect of our device in a real environment with naturalistic visual and sound cues. We also planned to investigate changes in the consumption of beverages associated with the use of our device.

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