Eating like an astronaut: How children are willing to eat "flying" food using acoustic levitation

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ABSTRACT

How food is presented and eaten influences the overall perceived eating experience. Novel gustatory interfaces have opened up new ways for eating at the dining table. For example, recent developments in acoustic technology have enabled the transportation of food and drink in mid-air, directly onto the user's tongue. Basic taste particles like sweet, bitter and umami have higher perceived intensity when delivered with acoustic levitation, and are perceived as more pleasant despite their small size (approx. 20μL or 4mm diameter droplets). However, it is unclear if users are ready to accept this delivery method at the dining table. Sixty-nine children aged 14 to 16 years did a taste test of 7 types of foods and beverages, using two delivery methods: acoustic levitation, and knife and fork (traditional way). Children were divided into two groups: one group was shown a video demonstrating how levitating foods can be eaten before the main experiment started and the other group was not. Our results showed no significant differences in liking of the foods and beverages between the two delivery methods. However, playing the video prior to the taste test significantly increased the liking and willingness to eat vegetables in the levitation method. Evaluative feedback suggested that a bigger portion size of levitating foods could be the game-changer to integrate this novel technology into real-life eating experiences.

CCS CONCEPTS

• **Human-centered computing → User interface design**; *Interaction design*;

KEYWORDS

Taste; Food Interaction Design; Acoustic Levitation; Food Delivery System; Taste Perception; Children Eating Behaviour

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1 INTRODUCTION

The field of Human-Computer Interaction (HCI) has traditionally focused on the use of visual and auditory modalities when designing user interfaces. This has changed with recent research linked to the study of food in everyday life (e.g., [3, 4]), the ecologies of domestic food consumption, as well as product and package design [7]; but mainly with the exploration of novel interaction concepts [10] (e.g., shape-changing food [13] and edible interfaces [2]).

Figure 1: Participants in a group of five during a hands-on levitation activity where they levitated and tasted different types of foods and beverages.

Recent applied research in acoustic technologies has shown great potential to further transform the exploration of the sense of smell and taste. For example, the TastyFloats system [11] can successfully levitate liquid and solid food morsels, considering the ambient temperature, the characteristics of the food items, and its effect on taste perception. It has been reported that perceived taste intensity (sweet, bitter, and umami) was higher when tasted in a levitation condition than in a non-levitation one. Also, the hedonic quality of the bitter taste was modulated in the levitation condition, making it a less unpleasant taste. The upgraded version of TastyFloats, called LeviSense [12], is the first platform that incorporates the stimulation of five human senses (taste, smell, vision, hearing and touch) in the context of levitating food. These platforms can be used as innovative tools for chefs to present their dishes, or to help customers to ingest bitter but healthy food (e.g., broccoli or codfish oil) encouraging the consumption of vegetables in children.

However, it has never been tested if customers, especially children, are willing to accept acoustic levitation as a food delivery method on their dining table. To answer this question, we conducted a user study with children to contrast the two distinct delivery methods: acoustic levitation (i.e., with TastyFloats), and traditional eating method (i.e., on a plate with knife and fork). Our results provide the first empirical insights on how children are willing to eat levitating foods. Based on the findings, we give suggestions to human-food designers and researchers guidelines on adapting this novel interactive platform to the dining environment.

2 TASTE EXPERIMENT

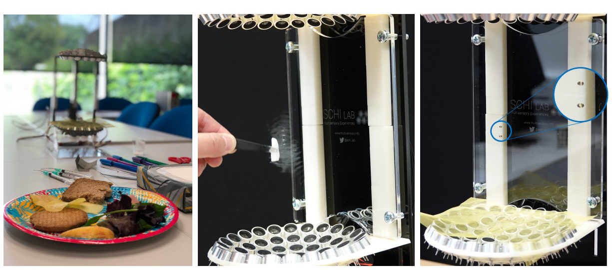
2.1 Study design

We conducted a mixed-design experiment, comparing:

- 7 types of foods and beverages: vegetable/salad, ham, crisps, biscuits, apples, milk, and cheese.
- 2 delivery methods: acoustic levitation using TastyFloats and traditional (on a plate).
- 2 conditions: in one condition, participants was shown a video demonstrating how levitating foods can be eaten before the main experiment started (the *"Video before" condition*) while in another condition, participants were not (the *"Video after"* condition).

Sixty-nine children (31 males, 38 females) aged 14-16 years (M = 14.94 years, SD = 0.29 years) participated in the experiment and were divided into four groups. Each group had a size of 17-18 children and participated in one workshop. The workshops were advertised as part of a participation activity to introduce young children to science and technology.

Taste stimuli: Seven common foods and beverages sourced from a local supermarket (©Co-op Food, UK) were used: vegetable/salad (Co-op Baby Leaf Salad 115g), ham (Co-op Honey Roast Ham 220g), crisps (Tyrrells Lightly Sea Salted Potato Chips 150g), biscuits (McVitie's Digestives Original Biscuits 400g), apples (Co-op Great British Apples 4 Pack), milk (Co-Op British Fresh Whole Milk 1 Pint/568ml), and cheese (Leerdammer Original Dutch Cheese 8 Slices 160g) (see Figure 2a).



(a) (b) (c)

Figure 2: (a) Selected foods given to children in a hands-on food levitation activity; (b) Visualising standing waves using dry ice; and (c) 2 droplets of levitating juice.

Demonstration Videos: Participants were shown four video clips during the workshop, as follow. Of the four video clips: clips 1 & 2 were shown at the beginning of the workshop, clips 3 & 4 were shown at different times depending on the condition of the group.

- **Clip 1**: *"British Astronaut Tim Peake shows how to drink water in space"* (https://youtu.be/6fXKtJcile8): to attract attention and set an inspirational theme for the workshop.
- **Clip 2**: *"TastyFloats: A Contactless Food Delivery System"*: showing system design and demonstrations of droplets levitation (https://youtu.be/ZQxgBs0mFPA).
- **Clip 3**: *"Presenters Are Amazed by the Taste of Floating Food! | Good Morning Britain"*: a live demonstration of how food and beverage morsels were levitated and eaten on iTV UK channel (https://youtu.be/sSglcz8TIAU).
- **Clip 4**: *"TastyFloats on BBC Clicks! Up, Up, and Away!"*: demonstrating how food and beverage morsels are eaten in a BBC Clicks! documentary (https://youtu.be/4Nh_i3Gb-Yo).

2.2 Procedure

The experiment was divided into four workshops, each with a group of 17 participants. Upon arrival, they were separated into 3 subgroups, each was assigned to a station with one TastyFloats unit (see Figure 1). The experiment consisted of three activities.

Activity 1: All participants in the group were first shown video clip 1, showing British astronaut Tim Peake demonstrating how to drink water in space, to set an inspirational theme for the event. They were then explained verbally by the workshop organisers about how the device works, as explained in [11]. Then, video clip 2 was shown, illustrating the underlying technology and design of TastyFloats. Afterwards, each sub-group practised with dry-ice to visualise the standing-wave patterns inside the levitator (see Figure 2b) and practised levitating polystyrene beads.

Activity 2: Once all participants had learnt how to levitate polystyrene beads. They started with actual food items. Each participant was handed a questionnaire, asking them to compare: liking (*"How much do you like the [food/ beverage name]?"*) and comfort (*"How comfortable do you feel in tasting the [food/ beverage name]?"*) of each food item (using a 7-point Likert scale from *1 = Not at all* to *7 = Very much*), with each delivery method: levitation and traditional (where they tried it on a plate with a knife and fork). Participants in the last two workshops were shown video clip 3 before the activity (the *Video before* condition), but participants in the first two workshops watched the same video clip (#3) at the end of the workshop (after activity 3 - the *Video after* condition).

Activity 3: Participants moved on to levitate beverage droplets. There were three shot glasses of milk, apple juice, and water. Participants were demonstrated how to levitate liquids, then tried to replicate this using 1ml syringes (with blunt needles - as in Figure 2a & c). Using the same questionnaire as in activity 2, they were asked to rate their liking and comfort for milk. Similar to activity 2, participants in the last two workshops were shown video clip 4 before starting the activity (the *Video before* condition), whilst participants in the first two workshop watched it after this activity (the *Video after* condition).

Finally, participants were asked two questions: (1) which delivery method they liked more to eat vegetables, and (2) what would be an ideal dish for the levitation delivery method.

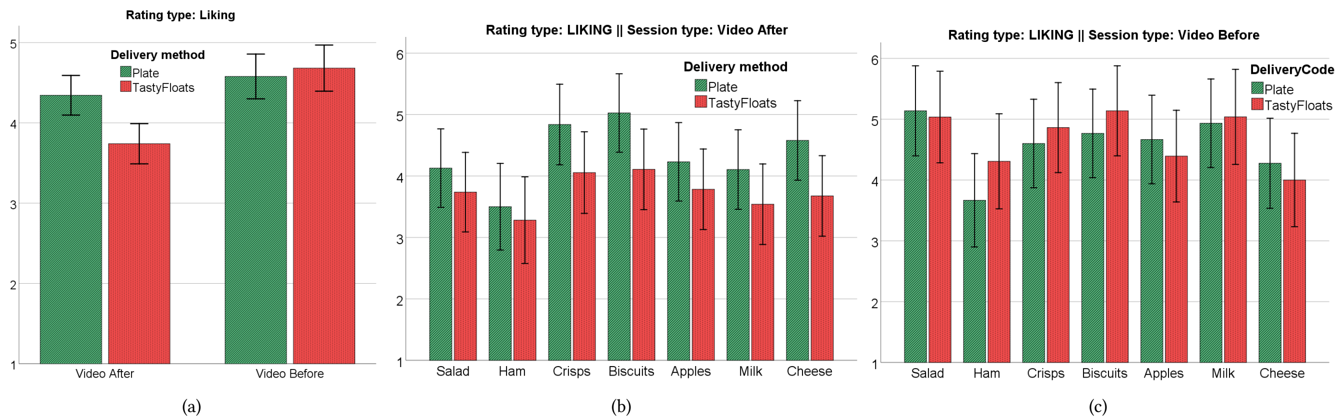


Figure 3: Average food liking ratings of foods and beverages split by: (a) condition (Video after vs. Video before) and delivery methods (Plate vs. TastyFloats); (b) & (c) difference in food liking between the two conditions in each food type.

3 RESULTS

We used univariate ANOVA to analyse the rating scores, with independent variables of delivery methods, conditions (or sessions - showing video clips before or after each activity), and food types. The results of each rating type: food liking and tasting comfort are reported separately below.

3.1 Liking

Overall, we found no significant differences in food liking between the two delivery methods: plate vs. TastyFloats ($F_{1,13.98} = 3.39, p = 0.66; M_{plate} = 4.46, SE = 0.10; M_{TastyFloats} = 4.21, SE = 0.10$). There was a significant difference between session types: showing the video clips before the activity resulted in higher food liking ($F_{1,77.48} = 17.78, p < 0.001; M_{video\ before} = 4.63, SE = 0.10; M_{video\ after} = 4.04, SE = 0.09$).

There was also a significant interaction between Session and Delivery methods, ($F_{1,28.03} = 6.79, p < 0.01$). Specifically, in the *Video afte*r condition, food liking in the TastyFloats delivery method (M = 3.74) was significantly lower than in the plate method (M = 4.34) ($t_{248} = 3.39, p < 0.01$, see Table 1 and Figure 3c). This difference was not found in the *Video before* condition ($p > 0.5$).

Similarly, we found a significant difference in food liking between video conditions for the TastyFloats delivery method: *Video after* (M = 3.74) and *Video before* (M = 4.68) ($t_{177} = -4.36, p < 0.001$, as illustrated in Table 1 and Figure 3a). Figure 3b & c also show the changes in food liking between the two conditions (*Video before* & *Video after*) of each food type.

3.2 Comfort

Univariate ANOVA found a significant difference between the two delivery methods (TastyFloats vs. plate) ($F_{1,207.83} = 43.97, p < 0.001$). Paired t-tests in each condition (*Video after* and *Video before*) showed significant differences between these two delivery methods: tasting foods and beverages from a plate was significantly more comfortable than with TastyFloats ($p < 0.001$) (see Figure 4 and Table 1 for more details). No significant difference was found between the two conditions (*Video after* vs. *Video before*) ($F_{1,0.34} = 0.07, p = 0.79$). No significant interaction was found between conditions and delivery methods.

	LIKING		**COMFORT**	
	Video before	Video after	Video before	Video after
Plate	4.58 ± 0.14	4.34 ± 0.13	4.40 ± 0.15	4.47 ± 0.13
TastyFloats	4.68 ± 0.15	3.74 ± 0.13	3.47 ± 0.16	3.48 ± 0.14

Table 1: Mean ratings (± SE) of food liking and tasting comfort in the two delivery methods (Plate vs. TastyFloats) and in each condition (Video after vs. Video before).

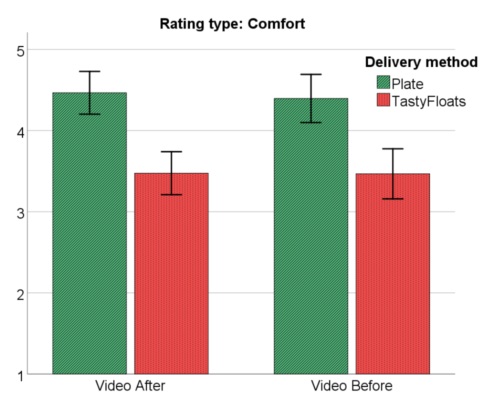
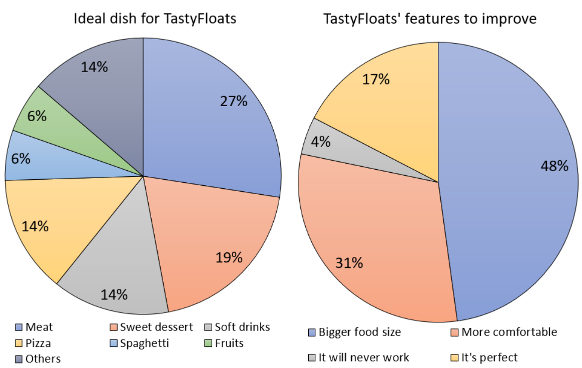


Figure 4: Average rating scores ($\pm SE$) of tasting comfort across all 7 types of foods and beverages.



(a) (b)

Figure 5: (a) Ideal dishes for TastyFloats, and (b) most wanted features on TastyFloats.

3.3 Eating vegetable and ideal dish for TastyFloats

We performed a paired t-test to compare the scores of *"willing to eat vegetable"* using each of the delivery methods. No significant difference was found between TastyFloats ($M = 5.10 \pm SD = 0.37$) and plate ($M = 5.41 \pm 0.41$) ($p = 0.49$).

On the comment of an ideal dish for TastyFloats, participants were excited to have daily common foods on their dining tables, such as meat (i.e., ribs - 27%), sweet dessert (i.e., cakes - 19%), soft drinks (i.e., juices - 14%), pizza (14%), spaghetti (6%), fruits (6%), and others (14%) (see Figure 5a).

When being asked about what would be the "game-changing" factor of having TastyFloats in the context of eating and tasting, about half of participants (48%) were eager to have bigger pieces of food levitated. Consistent with the finding that it was not as comfortable to taste foods as with a plate, 31% of participants wanted the device to be more comfortable to use. Interestingly, 17% of participants thought the device would already be ready to use on the dining table, while 4% of participants did not anticipate the device to work and did not wish to use it in their home (see Figure 5b).

4 DISCUSSION

In this work, we present the first study to investigate children's perception and willingness to accept levitating foods and beverages.

4.1 Liking and comfort in using TastyFloats

Our results show that children found tasting foods and beverages not as comfortable as in the traditional manner (on a plate). One main reason was because the unit given to them was only to levitate food and drink morsels. This required participants to actively take the levitating morsels inside the devices, resulted in a less convenient eating manner. A better approach would be incorporating the transportation unit, as presented in [11] or the full multisensorial platform (LeviSense [12]) where foods morsels are transported directly onto the participant's tongue.

Despite being less comfortable, participants found tasting food and beverage morsels using TastyFloats equally pleasant as the traditional method (i.e., on a plate). This is encouraging to apply further improvements to this novel delivery method. Specifically, it is possible that if levitating foods are designed to be eaten more comfortably, the pleasantness would be higher, possibly more than the traditional method. This is in-line with previous findings in [11] where participants found levitating droplets (i.e., of sweet and bitter) tasted more pleasant than having the same taste droplets dropped on their tongues.

4.2 Using video instructions

Our results show that it is beneficial to demonstrate to children previous examples of other people tasting foods and drinks, especially from familiar figures (i.e., TV presenters). We found significant higher food liking, albeit the same level of comfort, when children had viewed the demonstrating video clips before the tasting activities. This is an important lesson for human-food designers or chefs in using acoustic levitation to levitate foods and beverages on a real-world scenario (i.e., on a dining table). Incorporating these instructional video clips should be a part of the tasting experiences, and should be done prior to the activity.

4.3 Future works

In this work, participants were introduced to new delivery methods for the first time. Hence, it is possible that participants were more excited to try the new tasting experience. A follow-up work should investigate how the taste perception (i.e., liking and comfort) changes when participants are already familiar with the delivery method (i.e., invite participants back to repeat the experiment).

It should be noted that the food and beverage morsel's size was constrained by the technology limitation (i.e., maximum size of about 4mm in diameter), albeit multiple morsels can be levitated and tasted at the same time. Future investigations can harness further advance in acoustic technology to increase the size of levitating particle (as in [1, 5]), consequently to improve user's tasting experiences, including food liking and tasting comfort.

In the present experiment, we investigated children's perception of foods and beverages, but only attending to taste. However, eating is a multisensorial experience, that involves all of human senses [6, 8, 9]. Therefore, future investigations should involve more senses (i.e., vision, smell, and touch) in their investigation, and use an appropriate platform for this task such as LeviSense [12].

5 CONCLUSION

We conducted the first study with 69 children to investigate their taste experience (i.e., liking and comfort) of eating levitating foods and beverages. Our findings support the potential of designing levitation-based gustatory interfaces in the field of human-food interaction, as well as in real-life scenarios (i.e., on a dining table).

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[Removed for blind review]

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