Measuring Behavior 2016
10th International Conference on Methods and Techniques in Behavioral Research
25-27 May 2016, Dublin, Ireland

Measuring food choice and consumption behaviour with real, fake or virtual food realities – a comparative approach from the RICHFIELDS program

B.E. Mikkelsen, T. Bucher[2,3], S. Hieke[4], M.C.D. Verain[5] and J. van den Puttelaar[6]

1 Captive Foodscape Studies; Dept. of Clinical Medicine; Aalborg University; Copenhagen, Denmark, bemi@dcm.aau.dk

2 Institute of Food, Nutrition and Health, ETH Zurich, Zurich, Switzerland. tbucher@ehz.ch

3 School of Health Sciences, The University of Newcastle, Newcastle NSW, Australia. tamara.bucher@newcastle.edu.au

4 German Institute of Food Technology (DIL), Quakenbrück, Germany. s.hieke@dil-ev.de

5 LEI Wageningen University and Research Centre, Wageningen, Netherlands. muriel.verain@wur.nl

6 LEI Wageningen University and Research Centre, Wageningen, Netherlands. jos.vandenputtelaar@wur.nl

ABSTRACT

Introduction: Understanding and modelling food choice is of significant interest to public health policy makers, food retailers, caterers as well as food and nutrition researchers. Behavioural nutrition and the study of pathways leading to food choice is a growing field of scientific inquiry and with recent developments in information and communications technology (ICT),) new avenues have opened for research in this field. A number of lab facilities have been set up to study behaviour and food choice. These facilities offer a range of possibilities to study food choice, purchase and consumption.
Purpose: The aim of this paper is to give an overview of selected food labs and discuss the options they present for consumer research. The paper presents how real, fake and virtual food realities can be used for food choice and behavioural nutrition experiments.
Methods: The paper analyses the strengths and weaknesses of three example food labs. It looks at real food approaches in the "Restaurant of the future" (NL) and the FoodScapeLab (DK) as well as the fake food approach at the Fake Food Buffet (CH) and cases of virtual food reality where food choice experiments can be done on-screen before carrying out an experiment with real foods.
Results: The examples of lab facilities designed to experiment with behavioural nutrition presented in this paper all offer new potentials for convenient and easy data-collection about behavioural nutrition. While settings with real food have the advantage of presenting the most familiar context for participants, it also involves higher costs and less reproducibility than when using fake foods. Regarding virtual food reality, it can lower costs even more and facilitates data collection, but its higher unfamiliarity and unknown validity need to be taken into consideration.
Conclusion: While lab based collection of data offer new avenues for studying food choice under experimental conditions the development and maintenance of such facilities is both knowledge, labour and cost intensive. Increased cooperation, knowledge sharing and research infrastructure creation would be ways to meet that challenge.

Introduction

Food choice is complex, and is influenced by numerous determinants. Studies have shown that contextual factors such as social interactions, meal duration, eating atmospherics or distractions influence food consumption [1, 2]. Besides ambient influences, cues directly related to food or the way in which it is presented can also unconsciously influence consumption volumes. In order to understand how eating and choice environments influence behavior and how they can be effectively restructured to promote healthier choices the ability to carry out experimental modelling of food choice within controlled

environments is essential. Recent developments in information and communication technology (ICT) have created new possibilities for research in the field. A number of lab facilities have been set up to study behaviour and food choice. These facilities differ in the food studied and in terms of whether they focus on purchase or consumption.

The aim of this paper is to give an overview of these recent approaches to food labs. The paper presents how real, fake and virtual food realities can be used for food choice and behavioural nutrition experiments. The paper presents an overview of the three approaches to experimenting with behavioural nutrition, with a focus on the advantages and drawbacks of each set-up and suggests directions for a future research infrastructure in this field.

Methods

The three cases cover the Fake Food Buffet at ETH Zurich (food choice), the FoodScape Lab at Aalborg University (food choice, consumption) and the Restaurant of the Future at Wageningen University (food choice, purchase and consumption). These three facilities were selected because of their geographical spread across Europe and because they cover all three behavioural aspects: food choice, purchase and consumption of food, at various levels of external validity: virtual foods - fake foods - real foods - real restaurant setting. Furthermore, they all employ different IC technologies and devices to capture and store the data. The three cases cover the FoodScapeLab at Aalborg University (food choice, consumption), the Restaurant of the Future at Wageningen University (food choice, purchase and consumption) and the Fake Food Buffet at ETH Zurich (food choice). These three facilities were selected because of their geographical spread across Europe and because they cover all three behavioural aspects: food choice, purchase and consumption of food, at various levels of external validity: virtual foods - fake foods - real foods - real restaurant setting. Furthermore, they all employ different IC technologies and devices to capture and store the data.

1. FoodScapeLab (DK)

The FoodScapeLab is a real and virtual food lab where behavioural studies can be done. It was developed for the teaching in food choice dynamics at the Integrated Food Studies [3]. The laboratory space is divided into 3 areas: COOK, SERVE and EAT, depending on the food choice focus of the research protocol. In the FoodScapeLab experiments with virtual food and real foods can be conducted. It serves as a base camp and a docking station for maintenance and calibration of the devices that are used to collect data on food choice behaviour. Conceptually, the lab is founded on the idea that it is possible to define foodscapes as a conglomerate of food, people and spaces [4], and the purpose of the lab is to make it possible to study the interactions taking place in foodscapes. Common for the data that comes out of the lab is that they all come in a very structured format. All analyses are done in the ANALYTICS section, where collected data are interfaced with background data, for instance from food composition databases or databases on carbon equivalents or ingredient prices. The devices and functionalities in the lab dealt with in this paper are related to the intelligent buffet (IB) and the foodscape tracking (FT) that both use real food and the virtual food choice simulator (VFCS) that uses virtual food reality.

Intelligent buffet. The intelligent buffet comes in a mobile (mIB) as well as in a stationary version (IB) [5,6]. The technology is designed to automatically detect food choices under experimental conditions (FoodScapeLab) or outside the lab under field conditions (living lab foodscapes). It is a traditional buffet, which has been further developed and equipped with eight scales and sensors based on RFID technology. The technology builds on the insights from the Dietary Intake Monitoring System (DIMS) that offers intelligent monitoring of food intake technology [7]. The IB operates without the digital cameras, but uses the same scales and RFID reader technology. In the IB experiment, the subjects, when enrolled, are given a RFID bracelet in order to easily register events at the buffet. The sensor detects the person via the bracelet, and the amount taken from a particular scale. The structure of the output can be seen in Table 1. Each record in the output is similar to one “event” in other words, they corresponds to every time a subject would take anything from the buffet. To sort out any disambiguation in the output, recordings from overhead cameras connected to Observer XT software can be used. In the mobile version the scales come as stand alone scales that can be placed as needed in the food environment. A typical IB experiment setup is as follows; first, the protocol for the trial is developed describing what kind of hypothesis to test. When the action has been defined and IB is set up, the test subjects are recruited. Video recording equipment is set up to record the full experiment as an extra security. The test persons are registered and enter the EAT area of the laboratory. They make their food choices, while their behaviour is recorded by IB controller software

and the overhead video cameras. Apart from the requirement that people use their RFID tag before they take the food, there is nothing unusual and therefore minimum bias. When the experiment is completed, researchers and students retreat to the ANALYTICS area and analyse the data, e.g. in terms of nutrient content or climate impact.

Table 1. Intelligent Buffet data output.

Subject, no	**Time,** hour: minute: second	**Change of weight,** grams	**Scale,** no
1	00:01:55	23	1
5	00:02:59	50	8
8	00:01:39	76	7
9	00:01:49	34	6
3	00:02:51	55	5
4	00:01:50	67	5

Foodscape Tracking (FT). The foodscape tracking technology [8] follows the motion pattern of the consumer in the micro foodscapes and can be used to track for instance food choice dynamics around a buffet. It operates in an experimental mode, where sensors are set up in the foodscape, where the test persons are expected to make their choice. Instead of detecting the physical presence of consumers the FT detects the signal from the phone through the MAC address. GeoTags can then be attached to illustrate the motion pattern of the individuals studied. At the same time context sensitive questions can be asked in real time and can be compared to the answer the respondent given previously in a background questionnaire. It allows a real time ethnographic approach, where the consumer is asked in the actual behavioural situation. It can, for example, be used to investigate the difference between "saying" and "doing". In a study on secondary school students eating habits during the lunch break, we found that a third of the students who responded that they never went outside the school to eat, were actually tracked at one of the food stores or fast food places that were included in the study [8]. It should be emphasized that the smart phone version of the FT technology requires informed consent of all parties. The tracking technology comes in a slightly different, anonymous version –the Foodscape Heatmapping [5]. It is based on visual tracking of consumers using thermal cameras. This method of behavioural analysis is relatively new. It allows automatic collection of a much larger amount of data quickly, cheaply and objectively compared to manual methods. The technology has so far been used in both open spaces and indoor sports facilities [9]. The thermal technology is well suited for analyzing human food choice dynamics since the identity of the people cannot be recognized from the thermal images. In addition, the technology is independent of light, which is the weakness of many camera-based solutions. In future experiments, this tracking technology will be used to analyze consumers' movements and choices. The data that can be returned in such kind of experiments are shown in the figure grid below (Figure 1) and is about the length of time (minutes) that a given person is in a given grid of the foodscape. The figure illustrates the type of output that the Foodscape Tracker can generate. In the example the pattern of three subjects around a buffet are tracked and calculations can be made on how long each subject is in each of the squares of the foodscape. The buffet is illustrated in the middle.

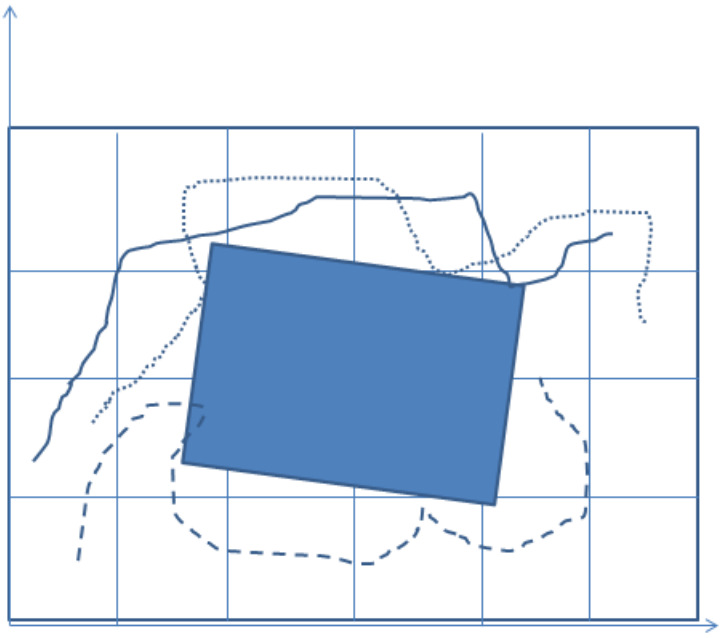

Figure 1. Foodscape Tracking data output.

C. Virtual Food Choice Simulating. As an alternative to using real foods in experiments and to save on purchasing dishwashing and food waste costs a 3D based virtual reality technology was developed under the brand name Virtual Food Choice Simulator (VFCS). The technology can be used to create a virtual food environment in which the consumer can make a virtual food choice. It can replicate buffets and supermarket without the cost of rebuilding and food. VFCS technology in the context of the Foodscape lab has been used in the study of consumer response to healthy check out aisles in supermarkets [10]. Based on questionnaires collected from customers in Lidl in a Copenhagen suburb, and their attitude to the possibility of having a healthy checkout options, a new design was developed for alternative layouts. The study found that only 10% of consumers had noticed the healthy checkout aisles. VFSC was used to develop various designs that could spice up the look. The new design was then tested in the virtual world among students and staff at the Aalborg University campus. The results showed that 83% of respondents with the new check-out design became more motivated to use the new check out aisles [11].

2. "Restaurant of the future" (NL)

The Restaurant of the Future is a real-life canteen with food lab facilities, situated on the Campus of Wageningen University and Research Centre. It consists of a buffet area with counters and a lunch area, where Wageningen UR employees and students, as well as visitors, can buy and consume their lunch [12]. For part of the participants, the Restaurant of the Future is their habitual lunch location; others are one-time visitors or go there for lunch occasionally. Daily visitors are useful in studies on dietary patterns and changes in habits due to changes in the choice context. The drawback of using daily visitors in studies with changes in the choice context is that they could become aware of these changes. Occasional or one-time visitor are interesting, when the aim is to study how they react to a specific choice context, but these one-time visitors have the bias of not showing habitual behaviour and being aware of the research context. This mix of participants is a strength of the Restaurant of the Future, although representativeness of the sample is naturally biased due to for example the large(r) number of highly educated people at a university campus.

Apart from a (semi-)natural context for the customers, the Restaurant of the Future provides a combination of opportunities for observational research and changeable surroundings. The combination of control over the surrounding,

observation methods, and a population that comes in naturally makes this a distinctive research facility. The research population that enters the premises by themselves are first attended towards the possibilities of participating in a study. Upon payment, first time visitors should give a statement of informed consent, to give permission to be monitored during their lunch. Visitors that come more regularly are registered with a registration card, which makes it possible to track their food purchases over a longer period of time. In addition, this would give researchers the possibility to contact these people with additional surveys for example. The order of the buffet and the positioning of the food are changeable, as well as price labels and food information. In the lunch area, there is the possibility to change the arrangement of the tables, for example by combining small tables into one big table where many visitors can sit together. In addition, colour of the lightning, music and scent can be changed. Moreover, possibilities are present to change the infrastructure.

The unique set-up with cameras provides the opportunity to track visitors in the buffet area as well as the lunch area. The cameras can be controlled from a control room, including possibilities to zoom in on certain visitors. Images can be stored and analyzed at a later point in time. This also means that researchers or clients do not have to be present all the time at the research location when the experiments are running. Unfortunately, the analysis of camera images is time-consuming. The set-up also gives little freedom to run multiple settings simultaneously, which limits the experimental designs that are possible. This unique facility, with a lot of flexibility in the choice context, and the presence of (tracking) cameras, makes the restaurant a useful location for pre-testing of branding and communication, and product or concept acceptation (out of home). Some more concrete examples of possible research topics are:

- Food purchases (e.g. reactions on price changes or on changes on food labels).
- Tracking of the walking route by use of (tracking) cameras.
- Insights in consumption behaviour over longer periods of time.
- Impact of changes in the environment (light, sound, smell, position).

In relation to other research methods the Restaurant of the Future gives the opportunity of combining a number of techniques to study food behaviour in relation to long-term behavioural change. The Restaurant of the Future gives a unique insight by combining the possibility of habitual behaviour with cash register data per person per unique product, camera view possibilities, pathway tracking and combinations thereof.

3. Fake Food Buffet (CH)

Experiments in real life venues are difficult to control, as settings change constantly and consumer environment interactions are highly complex. Furthermore, experimental research involving real food is often limited by practical problems such as high costs, limited availability of suitable infrastructure, and the effort of preparing food. Therefore, traditional food choice experiments were often limited to very simple food selections or only single food items. The fake food buffet (FFB) is an experimental method, which can overcome these common practical limitations by using food replicas to investigate daily food choice under controlled laboratory conditions. The method allows conducting food choice experiments (e.g. product choice, portion size choice or meal composition) in under well-controlled laboratory conditions. The FFB is a buffet where consumers are invited to select meals from a range of very realistic replica foods, as used for displays [13]. The tool allows the investigation of nutrient and health claims or nutrient information on food choice, nudging effects or educational interventions as well as other manipulations under controlled laboratory conditions. In a typical FFB experiment, participants are invited to choose portions, products, meals or diets from a variety of fake food products, which appear authentic and can be portioned continuously. The foods on the buffets are carefully pre-selected and arranged by or in collaboration with nutrition experts, and they are linked with a nutrition database. Foods, portions, meals or diets selected by participants can be evaluated efficiently and are compared between experimental conditions. The method has been shown to be reliable and valid [14], and has been used in several studies, e.g. to assess how nutritional information affects consumers' meal composition in response to information [15], or to investigate whether an increase in vegetable variety is a promising strategy to improve adults' and children's food choices [16] [17]. Meanwhile, two laboratories in Europe and one in Australia have implemented the method, and two new facilities are planned in 2016. Fake food experiments are limited to food selection, as the replica foods cannot be consumed. However,

the particular strengths of the method are the high controllability of various environmental cues and the cost effectiveness, which allows the investigation of food choice behaviour on complex offers.

[Please insert table 2]

Discussion

A variety of methods can be used to assess food consumption behaviour. Table 2 provides an overview of the real, fake and virtual food experimental technologies available in the three studied food labs as well as an assessment of the strengths and weaknesses. The technologies and methods can be used to answer a broad range of research questions. For instance whether taxes would be effective on changing choices or whether modelling of choice dynamics would lead to shift in choice and could be cost effective. This could in turn lead to recommendations for public health interventions. Pilots at different stages give different degrees of freedom and drawbacks. In the restaurant for example, a classical controlled experiment is not possible, which makes it difficult to run and compare multiple changes simultaneously. These drawbacks can be balanced by the use of other techniques like a virtual choice simulator [10,11] or a fake food buffet. A facility like the Restaurant of the Future, however, can shed light on changing of behaviour over time, but only in this specific context. A large part of daily consumption takes place elsewhere. To map this consumption behaviour, one needs to rely on alternative (preferably also low invasive and not self-reported) observations like smartphone apps and other trackers that people naturally take to their daily environments and activities. While many studies often have mixed results, the combination of all these techniques can shed light on the true nature of behaviour, from a fake food buffet to a real restaurant, when the data is comparable better insights into consumer behaviour can be ascertained.

With the increased need for insights in consumer food choice, there is a great need for facilities that can test choice dynamics and mechanisms underlying food choice in environments approach real life settings as close as possible. A broad range of stakeholders are potential users of such insights. And with the increased availability of intelligent devices, lab-based approaches to studying consumer choice and the role of food choice architecture is spreading, and recent developments in ICT have created new opportunities for researchers in the field of eating behaviour and food choice. We have identified and compared three of these. We conclude that they all offer new and innovative potentials. Regarding the food used, they represent the spectrum from real food to fake foods and virtual foods. Each of these labs offers strengths and weaknesses that will need to be considered when deciding on the concrete research questions and the study design. The food labs have followed slightly different directions in terms of the food studied and in terms of whether they focus on purchase or consumption. The initial insights from the study suggests that developing laboratory facilities for the study of human food choice is costly and knowledge intensive. In addition, the maintenance and operation of the facilities is costly in terms of validation, calibration and service and in all cases it requires permanent staff to manage these activities. More cooperation between the researchers and linking the facilities can make better use of the efforts stated above and make them more effective. In the future, research facilities and researchers could benefit by combining the different research methods and the data. In order to do so, standardized protocols are needed to compare, combine and link the data to finally reach more insights into food behaviour. Setting up a Research Infrastructure for sharing food data is a first step towards this future. These possible benefits should facilitated by the European strategy for food research infrastructure (ESFRI).

Acknowledgements.

The present paper is one of the results from the Workpackage 8 and10 of the Richfields project. The development of the technical equipment at the Foodscapelab at AAU have been supported by the Danish Agency for Technology, Science & Technology through the dVices4food program. The Virtual Food Choice Simulating devices were developed as part of the Foosions program with the support of the AAU matchmaking program. The Intelligent Buffet (IB & mIB) and the

Foodscape Tracker (FT) were developed in cooperation with Michal Dobroczynski, Syscore. The RICHFIELDS program is funded under the H2020 program.

References

1. Wansink, B: Environmental factors that increase the food intake and consumption volume of unknowing consumers. Annual Review of Nutrition, 24:455–79, 2004.
2. Wansink, B Mindless Eating: Why We Eat More Than We Think. Bantam Books, New York, 2007.
3. Mikkelsen, BE & Justesen, L: Multi disciplinarity in higher educations for the captive foodscape profession – case of Denmark, in symposium "Research based educations for future foodscapes – the New NordicFood4Many Experience. In Opportunities and Challenges for Food and Eating in Society. *Proceedings of The International Conference on Culinary Arts and Sciences.* Editors Feldman, C & Murra, D. Publ. by The College of Educ. & Human Services, Montclair State University, p 262- 263.
4. Mikkelsen, B.E. (2011). Images of foodscapes. *Perspectives in Public Health*. **131**(5), 209-216
5. Mikkelsen, B.E., Dobroczynski, M.; Gade, R, Ofei, K.O.; Pawlowski, K.D. & Serafin, S. (2015). Forskere vil tracke forbrugernes adfærd [in Danish]. *Researchers track consumer behaviour*. Downloadable from www.videnskab.dk
6. Mikkelsen, B.E. & Dobroczynski, M. (2014). The potential of the Intelligent Buffet in measuring food intake in a laboratory setting. *Proceedings of Measuring Behavior 2014, Wageningen, The Netherlands, August 27-29, 2014 (Paper 60).* Editors: A.J. Spink, L.W.S. Loijens, M. Woloszynowska-Fraser & L.P.J.J. Noldus. www.measuringbehavior.org
7. Ofei, K.T., Holst, M., Rasmussen, H.H., Mikkelsen, B.E. (2015). Effect of meal portion size choice on plate waste generation among patients' with different nutritional status – An investigation using Dietary Intake Monitoring System (DIMS). *Appetite*. 91, 157-164Top of Form
8. Koirala, S. (2015) *Tracking smartphone with mobile SMS technology as dietary data collection method: A case study in Lynge School*. (Master's thesis at Integrated Food Studies) http://projekter.aau.dk/projekter/files/213622458/Final_Master_Thesis.pdf
9. Gade, R. (2015). *Taking the Temperature of Sports Arenas – Automatic Analysis of People*. PhD thesis. November 2014
10. Andersen, M., Brisson, P., Hald, P., Godtfredsen, D., Serafin, S., Mikkelsen, B.E. (2014). Validation of a Virtual Reality Tool to Test Consumer Response in Supermarket Settings. *Proceedings of Measuring Behavior 2014* (Wageningen, The Netherlands, 27-29 August 2014), p. 412-413. Editors: A.J. Spink, L.W.S. Loijens, M. Woloszynowska-Fraser & L.P.J.J. Noldus. <www.measuringbehavior.org>. Accessed 4 April 2016.
11. Cekatauskaite, V., Kwebiiha, P.F., Lindum, J., Pawlowski, K.D., Sørensen, J.R., Vejlund, C., Vilhelmsen, S., Mikkelsen, B.E. (2015). Designing a Healthy Supermarket Checkout Aisle Proofing the concept of Virtual Food Choice Simulator. *Proceedings from ICCAS 2015* (Montclair State University, New Jersey, June, 2015), p. 108-114.
12. Van Herpen, E., Immink, V. & van den Puttelaar, J. (2016) Organics Unpacked: The Influence of Packaging on the Sales of Organic Fruits and Vegetables. Manuscript submitted for publication.
13. Replica foods. Döring GmbH, www.attrappe.de.
14. Bucher, T., van der Horst, K., Siegrist, M. (2012). The fake food buffet – a new method in nutrition behaviour research. *British Journal of Nutrition*. **107**(10), 1553-1560.
15. Bucher, T., van der Horst, K., Siegrist, M. (2013). Fruit for dessert. How people compose healthier meals. *Appetite*. **60**(1), 74-80.
16. Bucher, T., Siegrist, M., van der Horst, K. (2013). Vegetable variety: an effective strategy to increase vegetable choice in children. *Public Health Nutrition*. **17**(6), 1232-1236.
17. Bucher, T., van der Horst, K., Siegrist, M. (2011). Improvement of meal composition by vegetable variety. *Public Health Nutrition*. **14**(8), 1357-1363.

"Food" Technology	Cases	Description of "food tech"	Description of data capture = outcome measure	Strengths	Weaknesses
Real food	FSL	A facility with a Cook, Eat & Serve area	Observer XT, Intelligent Buffet, Heat Mapping, eTracking	Familiarity	Costs, preparation, cleaning
Real food	WUR	A canteen set-up with a (real) buffet, counters and a lunch area.	Purchase data, video of the buffet and lunch area, tracking and possibilities to measure food waste.	A real-life canteen context	Data structure, costs, single experimental condition at one moment in time
Fake food buffet	ETHZ, UoN, Konstanz (and further labs planned in 2016)	A buffet with replica food items from which subjects choose from	Portion sizes, meal composition, applied knowledge, alignment with dietary guidelines (%GDA, RDA)	low costs, no cleaning, highly controllable environment, reproducibility and validity, experiments, assessment of meal composition (complex choices) environmental influences, applied knowledge	No consumption, or food odours
Virtual food	FSL AAU	A virtual food environment that (VFCS – virtual food choice simulator) can be shaped in any style and in which consumer can shop virtually	Software/hardware based (for instance put on shopping trolley, brought to check out aisle, purchased with "virtual money"	Low cost, easy to set up experiment, no cleaning, easy and fully automatic data capture	Unfamiliarity, unknown validity

Table 2. Overview of the real, fake and virtual food experimental technologies and the food lab affiliation