Design to Eat Smart! A Design Framework for Pervasive Interventions of Eating Habits-supplementary material

A THE DESIGN FRAMEWORK

Level	Dimension	Values							
Theoretical	Persuasive Strategies	Feedback	Education	Self-control	Advice & Reminder	Monitoring	Social influence	Food estimation	Goal setting
Practical	Technology Modalities	Gaming	Application	Website	Smart device	Tableware	Multimedia		
	Stage	Single-process			Multiple-process				
	Timing	Before-meal		During-meal		After-meal			
	Frequency	Per-meal		Daily		Weekly			
	Social	Single			Group				
	Personalization	General			Tailored				

Figure 1: Design framework elements extracted from a review of key papers (N=62) for eating intervention design.

B THE PARALLEL COORDINATES OF THE PAPERS SURVEYED

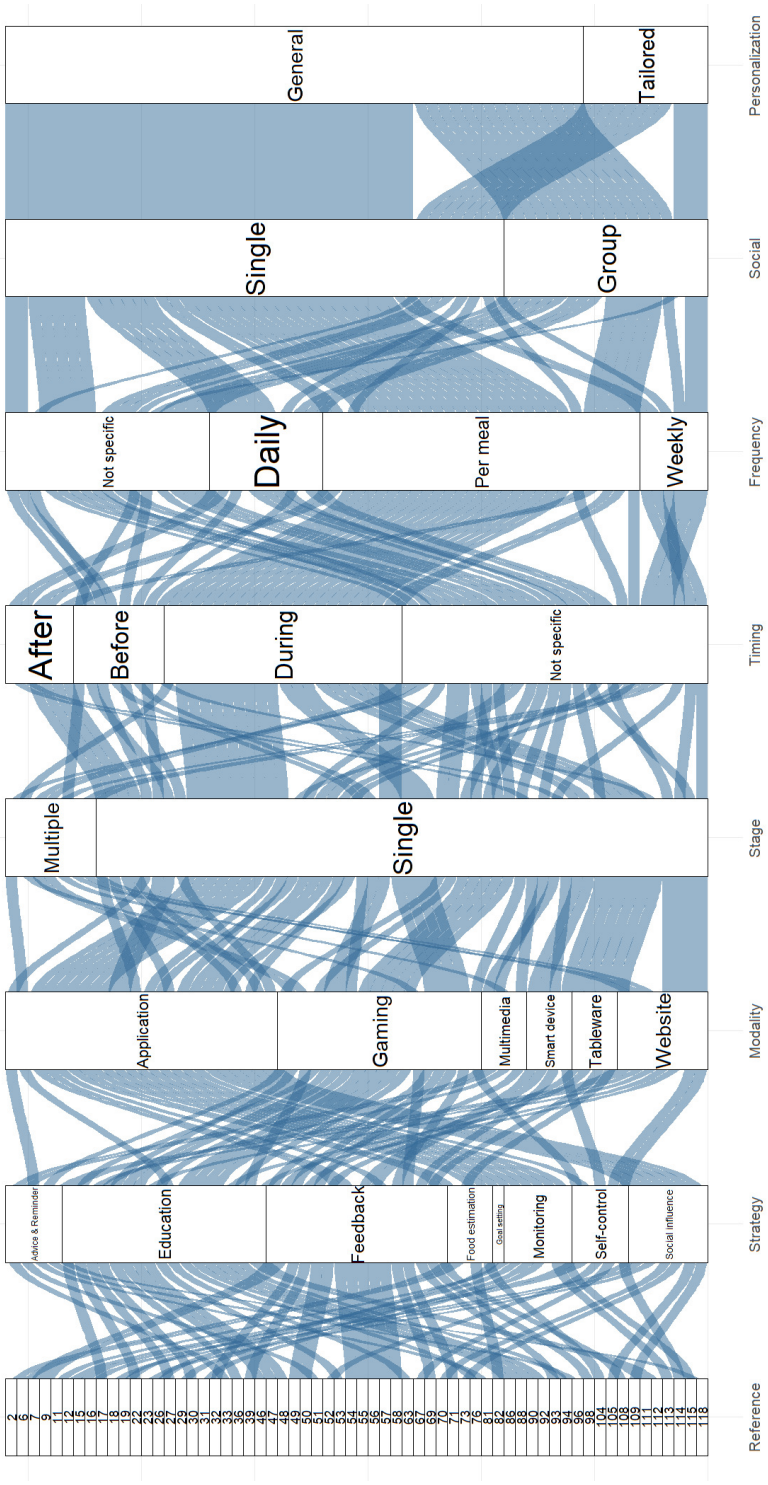

Figure 2: Parallel coordinates of the papers surveyed and categorized using design dimensions of the framework (N = 62).

C THE DESIGN BRAINSTORMING STUDY

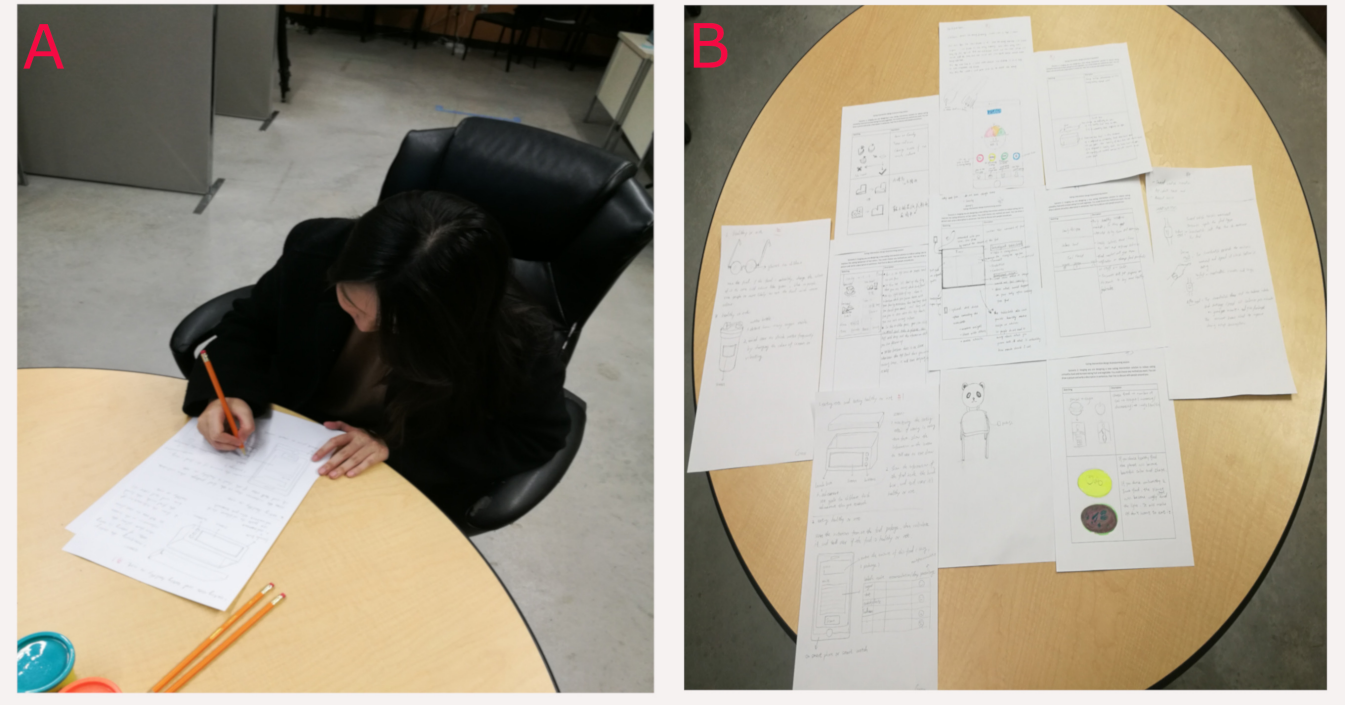

Figure 3: A design brainstorming study was conducted to test our framework. A: A participant sketching design ideas during the design brainstorming study. B: The sketches produced during the brainstorming session.

D THE DESIGNS FROM THE PARTICIPANTS

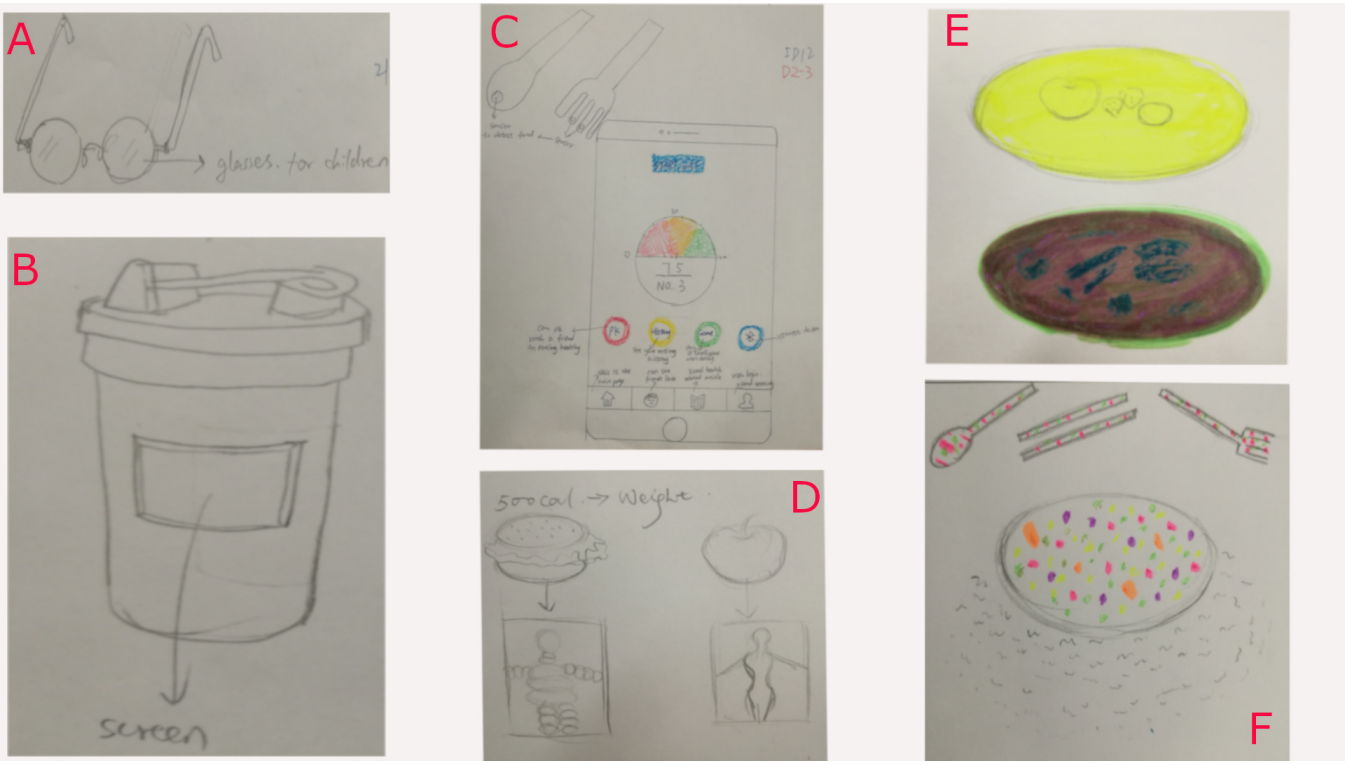

Figure 4: Designs were sketched by the participants. A (D1-3) are smart glasses which can change color of the glasses to provide feedback. B (D1-4) is a smart water bottle with a display to remind users to drink water and monitor water intake. C (D2-3) is an application to monitor eating. D (D5-1) is an application that can display body images based on the detection of the food. E (D5-2) is a plate which can display various colors and shapes based on the food on it to provide visual feedback. F (D5-4) is a plate with numerous lights which can flash and shake in order to provide visual feedback.

E ILLUSTRATIONS OF SIX DESIGNS FROM THE PARTICIPANTS

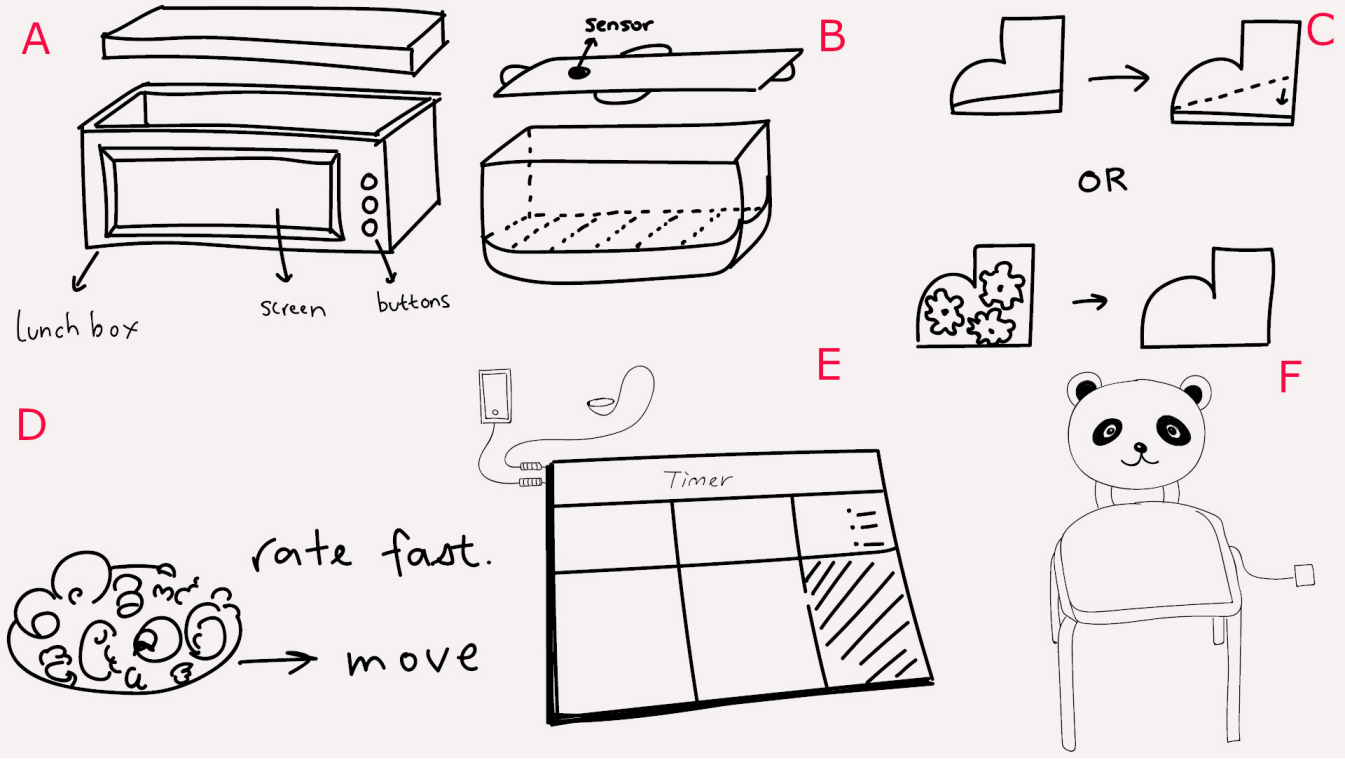

Figure 5: Six designs that were generated from the study. We asked graphic designers to illustrate them. The illustrations are shown: A is a lunchbox with a screen which can show the eating rate and provide feedback according to the healthy eating goal achievement (D1-1). B is a lunchbox with two levels which can lock the second level of food when it detects unhealthy food (D2-2) . C are smart shoes which can change the height of the bottom and shape of the outer layer logo to provide feedback (D3-4). D is a moveable plate that plat can move away from user to slow down eating rate (D5-3). E is a smart table cloth which can measure the food consumption by connecting tableware and can show the nutrition data and support video chat on the screen of it(D6-1). F is a chair which can provide music in order to influence children's eating rate and food consumption (D7-2).

F THE PARALLEL COORDINATES BASED ON THE DESIGNS FROM THE STUDY

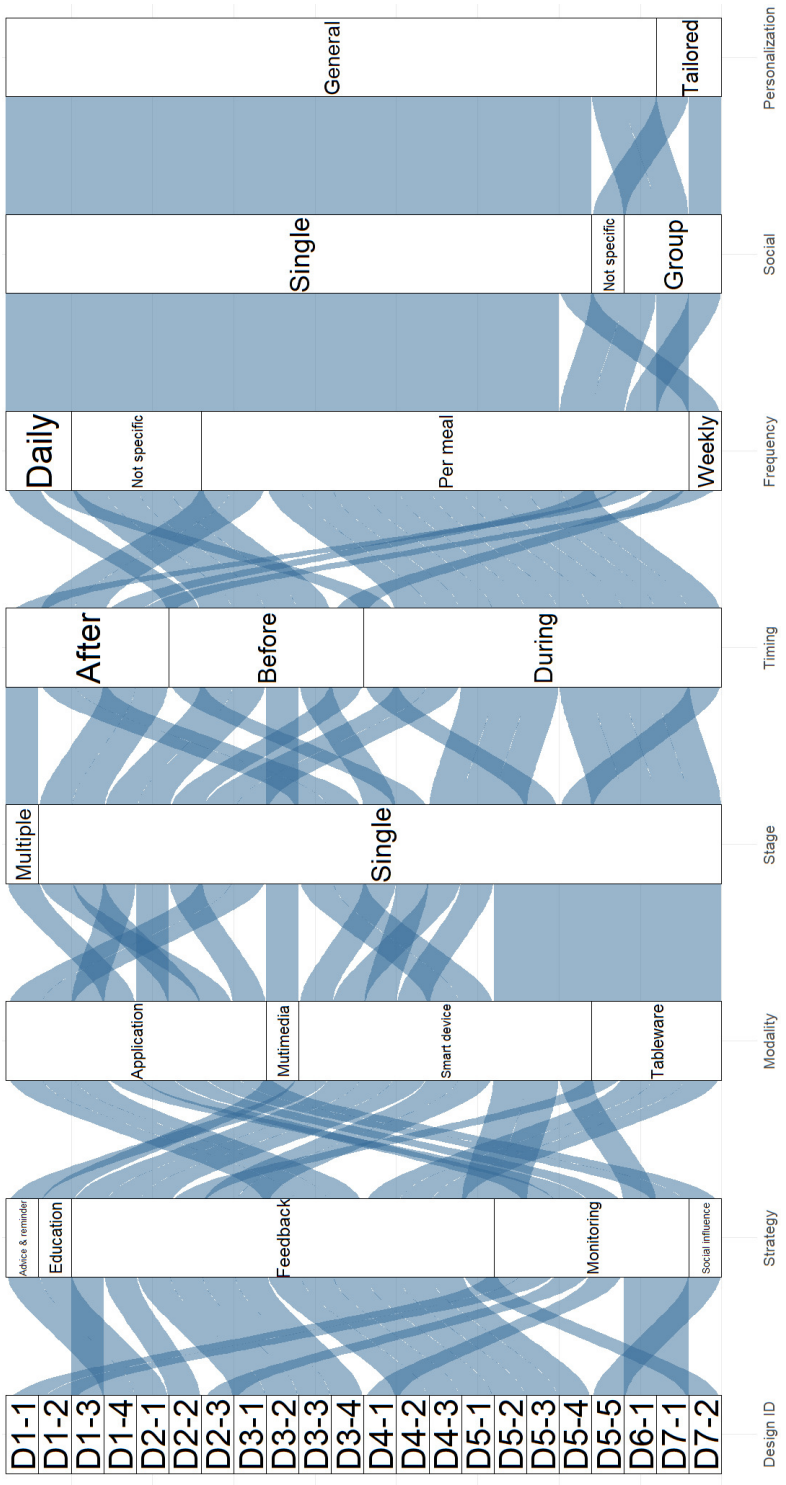

Figure 6: Parallel coordinates based on the designs generated by participants in the study using our proposed framework

G A COMPREHENSIVE OVERVIEW OF THE DIGITAL INTERVENTION DESIGNS ON EATING HABITS FROM LITERATURE REVIEW

Table 1: A comprehensive overview of the digital intervention designs on eating habits

Reference	Authors	Strategy	Modality	Stage	Timing	Frequency	Social	Personalization
[2]	Adams et al. 2015	Food estimation	Application	Single	During	Per meal	Single	General
[6]	Andreae 2017	Food estimation	Tableware	Single	During	Per meal	Single	General
[7]	Arza et al. 2018	Feedback	Gaming	Single	During	Per meal	Group	General
[9]	Bech-Larsen and Grnhj 2013	Feedback	Multimedia	Single	After	Daily	Single	General
[11]	Bird et al. 2013	Monitoring	Application	Single	Before	Not specific	Single	General
[12]	Blackburne, Rodriguez, and Johnstone 2016	Self-control	Gaming	Single	Not specific	Daily	Single	General
[15]	Brevers et al. 2017	Self-control	Application	Single	Not specific	Not specific	Single	General
[16]	Chang, Danis, and Farrell 2014	Social influence	Application	Single	Not specific	Not specific	Group	General
[17]	Chen et al. 2011	Education	Website	Multiple	Not specific	Weekly	Group	Tailored
[18]	Chung et al. 2017	Social influence	Application	Single	Not specific	Not specific	Group	General
[19]	Connelly et al. 2012	Monitoring	Application	Single	After	Per meal	Single	General
[22]	Cullen, Liu, and Thompson 2016	Education	Gaming	Single	Not specific	Not specific	Single	General
[23]	Eigen et al. 2018	Social influence	Application	Single	Not specific	Per meal	Group	General
[26]	Epstein et al. 2016	Goal setting	Application	Single	Before	Daily	Group	General
[27]	Fabri, Wall, and Trevorrow 2013	Education	Website	Multiple	Before	Not specific	Group	General
[29]	Ford et al. 2010	Monitoring	Application	Single	During	Per meal	Single	General
[30]	Frenn et al. 2005	Education	Multimedia	Multiple	Not specific	Weekly	Group	General
[31]	Freyne et al. 2012	Monitoring	Application	Single	Not specific	Per meal	Single	Tailored
[32]	Ganesh et al. 2014	Feedback	Gaming	Single	During	Per meal	Single	General
[33]	Gerber et al. 2009	Advice & Reminder	Multimedia	Single	Not specific	Weekly	Single	Tailored
[36]	Grimes, Kantroo, and Grinter 2010	Education	Gaming	Multiple	Not specific	Not specific	Single	General
[39]	Hermans et al. 2017	Feedback	Tableware	Single	During	Per meal	Single	General
[46]	Hwang and Mamykina 2017	Education	Gaming	Single	Before	Daily	Single	General
[47]	Joi et al. 2016	Education	Gaming	Single	During	Per meal	Group	General
[48]	Jones et al. 2014	Education	Website	Multiple	Not specific	Weekly	Group	Tailored
[49]	Kadomura et al. 2014	Feedback	Gaming	Single	During	Per meal	Group	General
[50]	Kadomura, Tsukada, and Siio 2013	Feedback	Tableware	Single	During	Per meal	Single	General
[51]	Kaptein et al. 2012	Advice & Reminder	Multimedia	Single	Not specific	Daily	Single	Tailored
[52]	Kehr et al. 2012	Self-control	Smart device	Single	Not specific	Daily	Single	General
[53]	Kim et al. 2011	Education	Gaming	Single	Before	Not specific	Single	General

Table 2: (Continued)

Reference	Authors	Strategy	Modality	Stage	Timing	Frequency	Social	Personalization
[54]	Kim and Bae 2018	Feedback	Application	Single	During	Per meal	Single	General
[55]	Kim and Bae 2018	Feedback	Application	Single	During	Per meal	Single	General
[56]	Kim et al. 2016	Feedback	Smart device	Single	During	Per meal	Single	General
[57]	Kim et al. 2016	Feedback	Smart device	Single	During	Per meal	Single	General
[58]	Kim, Park, and Lee 2016	Feedback	Application	Single	During	Per meal	Single	General
[63]	Kroes and Shahid 2013	Education	Application	Multiple	Not specific	Not specific	Group	General
[67]	Lawrence et al. 2015	Self-control	Website	Single	Not specific	Daily	Single	General
[69]	Lew et al. 2017	Feedback	Gaming	Single	During	Per meal	Single	General
[70]	Linehan et al. 2010	Social influence	Application	Single	After	Per meal	Group	General
[71]	Lo et al. 2007	Feedback	Gaming	Multiple	During	Per meal	Single	General
[73]	Lukoff et al. 2018	Social influence	Application	Single	Not specific	Daily	Group	General
[76]	Mansour et al. 2009	Education	Gaming	Single	Not specific	Not specific	Group	General
[81]	Nag, Pandey, and Jain 2017	Advice & Reminder	Application	Single	Before	Not specific	Single	Tailored
[82]	Narumi et al. 2012	Food estimation	Application	Single	During	Per meal	Single	General
[86]	Orji, Mandryk, and Vassileva 2017	Education	Gaming	Single	Not specific	Not specific	Single	Tailored
[88]	Orji, Vassileva, and Mandryk 2013	Education	Gaming	Single	Not specific	Not specific	Group	General
[90]	Park et al. 2015	Education	Gaming	Single	Not specific	Not specific	Single	General
[92]	Parker et al. 2013	Education	Website	Single	Not specific	Daily	Group	General
[93]	Pels, Kao, and Goel 2014	Feedback	Smart device	Single	After	Daily	Single	General
[94]	Peng 2009	Education	Gaming	Single	Not specific	Not specific	Single	Tailored
[96]	Pollak et al. 2010	Advice & Reminder	Gaming	Single	Not specific	Not specific	Single	General
[98]	Randall, Joshi, and Liu 2018	Feedback	Tableware	Single	During	Per meal	Single	General
[104]	Sakurai et al. 2015	Food estimation	Application	Single	During	Per meal	Single	General
[105]	Schaefbauer et al. 2015	Social influence	Application	Single	After	Per meal	Group	General
[108]	Sugita et al. 2018	Feedback	Application	Single	During	Per meal	Single	General
[109]	Takeuchi et al. 2015	Social influence	Application	Single	Before	Not specific	Group	Tailored
[111]	Thompson et al. 2010	Education	Gaming	Multiple	Not specific	Not specific	Single	Tailored
[112]	Thompson et al. 2012	Education	Website	Single	Not specific	Weekly	Single	General
[113]	Kaptein et al. 2012	Monitoring	Application	Single	After	Per meal	Single	General
[114]	Veling et al. 2014	Self-control	Website	Single	Not specific	Weekly	Single	General
[115]	Villalobos et al. 2011	Monitoring	Application	Single	During	Per meal	Single	General
[118]	Yang et al. 2017	Advice & Reminder	Website	Single	Before	Per meal	Single	Tailored

H DESIGN FROM THE DESIGN WORKSHOP

Table 3: A comprehensive overview of the designs from design brainstorming session

ID	Strategy	Modality	Stage	Timing	Frequency	Social	Personalization	Description
D1-1	Monitoring	Smart device	Single	During	Daily	Single	General	P1 designed a lunchbox (D1-1) with a screen and buttons on it. The screen would display the eating rate and present suggestions to regulate eating speed if the user eats too quickly. The lunchbox would also display information on the food to tell the user whether it is healthy or not. Users can set goals in the system and gain rewards based on achievements related to eating behavior improvement.
D1-2	Monitoring	Application	Single	Before	Not specific	Single	General	P1 designed an application (D1-2). When using the application, food is scanned and the application could perform calculations to inform the user if the food is healthy or not. The application can show recommended daily nutritional objectives for each nutritional category. The application can show percentages of consumption relative to a target, then provide emoji feedback.
D1-3	Feedback	Smart device	Single	During	Per meal	Single	General	P1 designed smart glasses for children (D1-3). The system in the glasses can scan the food and if the food is unhealthy, the color of the glasses will change to a cold color like green, blue, or purple. (P1 assumed the cold color could discourage eating).
D1-4	Advice & reminder	Smart device	Single	Before	Not specific	Single	General	P1 designed a smart water bottle (D1-4) with a display which can remind users to drink water by changing the display color and providing vibration feedback. The display can also show the sugar content of the water.
D2-1	Education	Mutimedia	Single	Before	Not specific	Single	General	P2 designed a solution (D2-1) for people who use YouTube. The design, which leverages advertisements on online video websites, proposes providing healthy eating video advertisements during YouTube video shows. This can help users to learn more about healthy eating improvement while consuming video media.
D2-2	Feedback	Smart device	Single	Before	Daily	Single	General	P2 designed a lunchbox(D2-2) with two physical levels. When users are filling food in the lunchbox, the box can detect the food type. If unhealthy food is placed in the lunchbox the lower level will not be available for food storage. This design restricts capacity of the box when filled with unhealthy food. When filled with unhealthy food, the lunchbox will be difficult to open, which provides feedback to users that the food is not suitable for them.

Table 4: (Continued)

ID	Strategy	Modality	Stage	Timing	Frequency	Social	Personalization	Description
D2-3	Monitoring	Application	Multiple	After	Per meal	Group	Tailored	P2 designed a smartphone application (D2-3) which can connect with smart utensils to detect eating behavior. Users can share their eating experience with friends and compete with each other in healthy eating development by using this application. The application can provide a score based on eating behavior and rank a user against their friends. The application will also provide personalized written content on healthy eating for users who receive a lower score. The application would also provide a small game for users to play while eating and a history record for users to review their eating behavior data.
D3-1	Feedback	Smart device	Single	During	Per meal	Single	General	P3 designed an earphone (D3-1) that can provide healthy eating suggestions when detecting unhealthy eating behavior.
D3-2	Feedback	Tableware	Single	During	Per meal	Single	General	P3 designed a set of novel chopsticks (D3-2) that can restrict the open angle of the chopsticks to control the food portion size in order to control eating speed.
D3-3	Feedback	Smart device	Single	After	Per meal	Single	General	P3 designed a gum or candy-like product (D3-3) that can change taste based on the caloric intake detected by the tracking system to help improve awareness after a meal. This is a novel feedback approach which is inspired by the fact that nowadays people like to have a gum or candy after their meal.
D3-4	Feedback	Smart device	Single	After	Per meal	Single	General	P3 designed a type of shoe (D3-4) that can change the height of the heel part and shape of the picture on the outer layer screen to provide after-eating feedback.
D4-2	Feedback	Application	Single	During	Per meal	Single	General	The second smartphone application (D4-2) designed by P4 provides suggested eating speed for different kinds of food based on the food detection. The application can provide ambient music to help slow down eating speed.
D4-1	Monitoring	Application	Single	After	Weekly	Single	General	P4 designed an application for smartphone (D4-1). The application would show daily healthy recipes for users to follow. It can also display the weekly caloric intake of a user. One feature of the application design is the "food market", which can present notifications of healthy food on sale in nearby supermarkets or grocery stores and provide coupons.
D4-3	Feedback	Application	Single	During	Per meal	Single	General	P4 designed an application (D4-3) for smartwatch users. The application could provide suggestions regarding food consumption. During a meal, the application could provide real-time vibration and sound feedback if eating speed is higher than suggested. After the meal, the application can show the caloric intake and eating speed, along with a summary of eating behavior to improve in the next meal.
D5-1	Feedback	Application	Single	Before	Not specific	Single	General	Participant 5 designed an application (D5-1) which could show different body images based on the detection of calories and food amounts when users scan food with a smartphone.
D5-2	Feedback	Tableware	Single	During	Per meal	Single	General	P5 designed a plate (D5-2), which can display various colors and shapes based on the food on it. If the food is healthy, the plate will show beautiful shapes and colors. If the food is unhealthy, the plate will display an ugly shape and color.

Table 5: Appendix B. (Continued)

ID	Strategy	Modality	Stage	Timing	Frequency	Social	Personalization	Description
D5-3	Feedback	Tableware	Single	During	Per meal	Single	General	The second plate designed by P5 is a movable plate(D5-3). When using this plate during a meal, the plate will move away from the user to make it harder to eat, if the user eats too quickly.
D5-4	Feedback	Tableware	Single	During	Per meal	Single	General	The third plate designed by P5 applies light on it (D5-4). This plate can display various lights which can flash or shake to provide visual feedback when users eat too quickly.
D5-5	Social influence	Application	Single	Before	Per meal	Group	General	P5 designed an application (D5-5) to apply social influence strategy. When using the application, users can choose the food they plan to eat. Users can make friends when the system matches them with people who choose the same group of healthy food. Subsequently, the friends can support each other to maintain healthy eating behaviors.
D6-1	Monitoring	Smart device	Single	During	Per meal	Not specific	Tailored	P6 designed a novel intelligent table cloth (D6-1) to control food consumption. The table cloth has the ability to connect smart tableware to measure food consumption and can connect to a smartphone to upload dietary data to monitor a meal. Users can use their phones to share information about dietary experiences and assist with creating dietary schedules. The tablecloth is portable and could be taken anywhere. It also has a screen which displays a timer, as well as nutritional and caloric data. The screen can also be used to show videos and images. The tablecloth could also support a single user to gain social interaction by having video chat on the screen. The tablecloth can provide personalized healthy menus, recipes, and advice for healthy eating according to user's data.
D7-1	Monitoring	Application	Single	After	Per meal	Group	General	P7 designed a diet-monitoring application for fast eaters (D7-1). The users of the application can share eating-rate related data with family members, who can then choose to award a star, based on the data. The user can take pictures to track the meal and the application can provide an alarm upon the detection of fast eating speeds.
D7-2	Feedback	Smart device	Single	During	Per meal	Single	General	P7 designed a smart chair (D7-2) which can provide music during eating to influence children's eating speed and amount of food consumption.

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