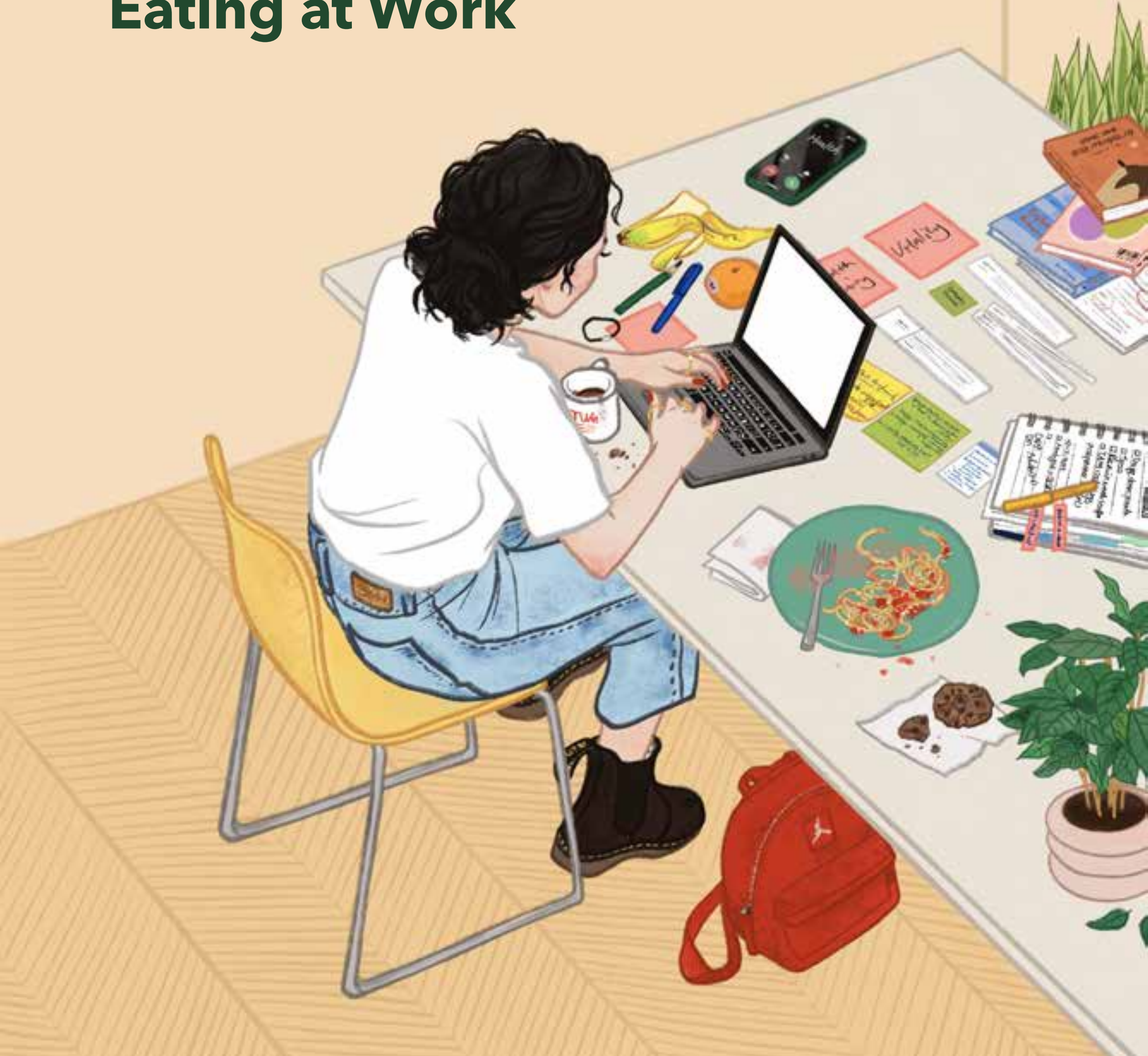
Exploring Design Opportunities for Promoting Healthy Eating at Work



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PROEFSCHRIFT

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Het onderzoek of ontwerp dat in dit proefschrift wordt beschreven is uitgevoerd in overeenstemming met de TU/e Gedragscode Wetenschapsbeoefening.

A note to readers

How to use this book

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Summary

Background and Motivation

A healthy eating behavior commonly appears to be a critical component that paves the way for individuals' vitality and health. The prevailing health problems associated with eating habits, such as cardiovascular diseases, cancer, type 2 diabetes, and suboptimal conditions linked to obesity, are increasingly affecting the working-age population. As diet-induced health problems are a growing public health concern, improving unhealthy eating behaviors and routines in the work context is an essential area of interest within the field of health promotion. In recent years, there has been a significant upswing in research and development initiatives focused on digital tools and interventions designed to encourage healthy eating behaviors. These emerging digital technologies have predominantly focused on tracking dietary consumption and delivering initial feedback through mobile applications, wearables, public programs, etcetera. However, these tools face challenges in achieving their goals if they do not effectively incorporate the promotion of healthy eating into individuals' daily routines or account for influential factors in a specific context. While current digital tools show a promising new field, relatively less attention has been devoted to developing interaction designs tailored to stimulate healthy eating patterns and routines in the work context. Consequently, this doctoral dissertation endeavors to provide an explorative perspective on the concept of healthy eating in the working context and aims to address the central research question: ***How to design digital tools to promote healthy eating in the working context?***

Research Approach and Outcomes

The aim of this thesis is to explore design opportunities utilizing digital tools equipped with interactive features for individuals (who have an office job without dietary treatments) to enhance the quality of food intake and subjective well-being during daily work. To answer the research question mentioned above, we use an exploratory design research approach and organize our research into four main parts: ***Understanding***, ***Exploring***, ***Envisioning***, and ***Reflecting***.

Understanding In the first part, we provide an overview of state-of-the-art design and eating-related technologies in the work context (Chapter 2) and understand current eating patterns and routines at work through empirical field explorations (Chapter 3). In **Chapter 2**, we conducted a scoping review, scrutinizing 16 papers. Our analysis focused on identifying key attributes, including objectives, theoretical underpinnings, and design approaches in these papers. Additionally, we mapped different types of technology and design to gain an increased understanding of dietary technologies that address healthy eating at work. Our findings revealed the potential for future research to concentrate on personalized, interactive, and playful digital tools in the field of human-computer interaction principles. Moreover, these tools should incorporate behavior change techniques and prioritize user-centered approaches to facilitate the adoption of healthy eating behaviors in day-to-day work routines. In **Chapter 3**, we conducted a user-centered contextual inquiry study based on mixed-methods, combining an online questionnaire with 54 participants and semi-structured interviews involving 12 participants. Through these investigations, we identified several contributing factors via context explorations, which can be summarized as follows: *concerns related to productivity*, *health and nutrition*, *energy support*, and *well-being* could significantly influence how individuals eat at work; and additional features, namely *social support*, *technology-assisted health programs*, *goal setting*, *self-tracking*, and *easy access to health information* should be integrated into the design of digital tools within the working context. Deriving insights from the contributing factors identified in the contextual inquiry study, we proposed EAT@WORK – an interactive application with four key features, including *supporting easy access to relevant knowledge*, *assisting goal setting*, *integrating with health programs*, and *facilitating peer support*. A within-subject study with a sample size of 14 participants showed that EAT@WORK was perceived as more useful and user-friendly compared to a benchmark app (Traqq). Additionally, these four features exhibited varying proportions in different work contexts (work from home vs. work in the office).

Exploring With these understandings in mind, the second part of this doctoral thesis unfolds through a combined Research Phase (Chapter 4) and Design Phase (Chapter 5). Here, we delve into the field of self-monitoring tools, aiming to discuss potential approaches for increasing self-awareness of daily food intake and stimulating healthier eating behaviors (e.g., healthy food choices and eating on time) in the working context. In the Research Phase outlined in **Chapter 4**, we draw inspiration from our scoping review (Chapter 2) and look at how mobile Health (mHealth) tools can facilitate healthy ways of eating in the work context. In our initial exploration, we employed Traqq, a dietary self-reporting application developed by researchers from Wageningen University & Research. Two self-reported dietary assessment methods were compared (4-hour Recall vs. Food Record) to monitor food intake during working hours. A four-week study involving 30 working-age individuals revealed that participants preferred the Food Record method over the 4-hour Recall method because of its more flexible completion time and lower mental burden during working hours. User insights from the study highlighted that integrating reminders into daily routines, simplifying the tracking process, and incorporating gaming elements are desired features for future design. In the Design Phase detailed in **Chapter 5**, we introduce the NutriColoring toolkit, which was developed to promote self-monitoring and self-reflection on daily food intake during working hours. Through a cultural probe study with 18 participants, our analysis showed that the Coloring approach employed in the NutriColoring toolkit provided users with a positive user experience, enhancing motivation in terms of reduced frustration and increased enjoyment. Interview results demonstrated a high acceptance of using NutriColoring at work, attributed to the freedom and playful engagement of intake reporting activities it offers.

Envisioning In the third part of this thesis (**Chapter 6**), we look ahead to the future, aiming to provide potential users an opportunity to articulate possible scenarios and imaginings about future dietary technology in the year 2040, which could serve as beneficial inspirations for designers to develop creative design concepts of Human-Food interaction. A Collaborative Ideation Approach that integrated scenario planning, the scenario method, and the co-ideation method was applied. A total of 97 stories for hypothetical future eating scenarios and technologies in 2040 were created by 116 participants, all of which were eventually included in the analysis process. Then, we organized a design experiment involving two groups of designers: an experimental group of 10 designers inspired by the 97 narratives to develop 32 concepts of future food technology, while a control group of another 10 designers created 31 concepts without narrative influence. Evaluation by three design experts using the Creative Product Semantic Scale revealed a significantly higher level of creativity in the concepts generated by the experimental group. Furthermore, qualitative analysis conducted through interviews with 20 designers confirmed that the narratives positively enhanced the creativity of design concepts for future food technology.

Reflecting The final part contains our conclusions and reflections. **Chapter 7**, the concluding part, draws together the contributions, provides answers to the research questions, and reflects on our research and design process. **Chapter 8** offers summarized implications and recommendations to inspire future designers and researchers when working with and for healthy eating in the working context.

Acronyms

ACM	Association for Computing Machinery
BCT	Behavior Change Techniques
CPSS	Creative Product Semantic Scale
HCI	Human-Computr Interaction
HFI	Human-Food Interaction
IMI	Intrinsic Motivation Inventory
mHealth	Mobile Health
NASA-TLX	NASA Task Load Index
ObW	Office-based Work
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
TAM	Technology Acceptance Model
UTAUTS	Unified Theory of Acceptance and Use of Technology 2
UX	User Experience
WfH	Work from Home
WHO	World Health Organization

CONTENTS

CHAPTERS

1 Introduction

1.1 Background

Unhealthy Eating as Major Public Health Concern

Unhealthy eating has become a major public health risk, as acknowledged by the World Health Organization (WHO) (World Health Organization, 2020b). According to the Global Burden of Disease study, unhealthy eating accounts for one-fifth of deaths globally and is responsible for higher mortality rates than several other risk factors, including smoking and high blood pressure, in the past decades (Afshin et al., 2019). Evidence also showed that unhealthy eating is one of the leading risks for the global burden of disease that results in malnutrition in all forms (i.e., undernutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, and obesity) as well as a range of eating-related noncommunicable diseases and conditions (e.g., obesity, cardiovascular diseases, and type II diabetes) (Afshin et al., 2019; Gakidou et al., 2017; World Health Organization, 2014).

Promoting healthy eating has become one of the primary goals of public health (Gorski & Roberto, 2015). According to the WHO, healthy eating behavior involves consuming a variety of foods that provide nutrients for maintaining health, energy, and well-being while guarding against malnutrition in all forms and noncommunicable diseases throughout the life course (World Health Organization, n.d.-b). To encourage safe and healthy food choices, the WHO recommends the following: (1) Meeting the needs of energy, protein, vitamins, and minerals through a varied food intake; (2) Obtaining the largest amount of energy from carbohydrates, mainly through legumes and wholegrain cereals; (3) Reducing total fats to less than 30% of total energy intake; (4) Reducing free sugars to less than 10% (ideally 5%) of total energy intake; (5) Limiting sodium intake to less than 2 grams per day; (6) Consuming at least 400 grams of vegetables and fruit per day in adults. Furthermore, the WHO also provides advice on encouraging healthy eating practices, for instance, raising people's awareness of healthy food intake, supporting point-of-sale information (e.g., front-of-pack nutrition labeling to facilitate understanding of nutrient contents in foods), and providing nutrition and dietary counseling at health-care facilities (World Health Organization, 2020b).

Moreover, healthy eating is a broad term that is not only related to "*what to eat*" (e.g., type of food and portion size) but also to "*when to eat*" and "*how to eat*" (e.g., eating alone/with others) (Emilien & Hollis, 2017). Regarding "***when to eat***", evidence shows that scheduling eating time is beneficial for helping individuals maintain a balanced and stable energy source, as the metabolism is engaged at optimal levels all day long (Garaulet & Gómez-Abellán, 2014; Lopez-Minguez, Gómez-Abellán, & Garaulet, 2019). Paoli and colleagues (Paoli, Tinsley, Bianco, & Moro, 2019) recommended a regular eating pattern with a three-meal-timing schedule, including consuming a higher proportion of energy early in the day, maintaining a consistent daily eating duration with regular fasting periods, as well as avoiding food intake close to a sleeping period (i.e., bedtime and early morning). A previous study (Manoogian, Chaix, & Panda, 2019) also revealed that optimizing eating interval offers considerable health benefits (such as reducing obesity) and may hold promise for future interventions promoting healthy eating. Regarding "***how to eat***", emerging evidence suggests that social influence plays an essential role in the development and maintenance of obesity (Higgs & Thomas, 2016). Individuals have different eating behaviors when they are in the company of other people (e.g., friends, colleagues, and family) compared to when they eat alone (Higgs, 2015). For instance, social impression (Vartanian, 2015) and peer comparison (Cruwys, Bevelander, & Hermans, 2015; Polivy & Pliner, 2015) significantly influence consuming less but healthier food than eating alone. Additionally, since most adults work and have at least one meal outside the home, the social influence in these venues (e.g., workplace and restaurant) has become a crucial area of research in recent years to encourage healthy eating practices (Devine, Connors, Sobal, & Bisogni, 2003).

Eating Activities at Work

Employment in desk-based occupations has been projected to climb to 3.5 billion worldwide since the advent of personal computers in the 1970s (Jochem, Schmid, & Leitzmann, 2018; Sven Smit, Tilman Tacke, Susan Lund, Washington, James Manyika, & Lea Thiel, 2020). The workplace (i.e., home office and office environment) is and could be one of the essential daily contexts influencing eating behavior, physical health, and mental well-being among working-age individuals (Glympi, Chasioti, & Bälter, 2020). Notably, a substantial proportion of working-age adults with full-time employment spend up to one-third of their waking hours in the same working environment each day (Allan, Querstret, Banas, & de Bruin, 2017), where approximately 60% of their daily food intake occurs (Panchbhaya, Baldwin, & Gibson, 2022). Given the considerable amount of time that working-age individuals spend on their jobs, working contexts present a vital venue with numerous opportunities to deliver and implement interventions aimed at stimulating healthy eating patterns (Clohessy, Walasek, & Meyer, 2019; Glympi et al., 2020; Panchbhaya et al., 2022).

As high-speed internet access has become more widely available, remote working in various contexts (i.e., office, home, coworking and shared office space, and other workplaces) has emerged as a new working mode in the past decades (Allen, Golden, & Shockley, 2015). The COVID-19 pandemic has further accelerated this working mode globally as a preventive measure to stop the virus from spreading (Kniffin et al., 2021). As a result, more and more working-age individuals prefer to shift their working mode from "working in an office" to "working from home (WfH)" (Alexander, De Smet, Langstaff, & Ravid, 2021). Moreover, as one of the remoting working modes, WfH has proceeded better than expected from the perspective of working conditions (Ozimek, 2020), demonstrating benefits such as improved productivity, job satisfaction and morale, reduced absenteeism, and better retention (Popovici & Popovici, 2020; Pridgeon & Whitehead, 2013). Evidence also states that remote working mode will be a new normal even after the COVID-19 pandemic

(Tan, Goh, Tan, & Tan, 2022). However, this trend also has challenges. For instance, eating behavior was practiced differently in the WfH context compared to working in the traditional office (Restrepo & Zeballos, 2020; Sato et al., 2021; Tan et al., 2022). Specifically, individuals spent ca. 1.7 times more time cooking and 2.6 times more time eating at home than the average (Restrepo & Zeballos, 2020). Additionally, the WfH mode has an impact on an individual's work-life balance — the working time patterns could be more irregular and unpredictable (Popovici & Popovici, 2020; B. Wang, Liu, Qian, & Parker, 2021). To address these issues, creating regular daily routines, including eating at the same time every day and making scheduled working routines, is suggested (Lopez-Leon, Forero, & Ruiz-DIáz, 2020). In other words, while the trend of WfH presents various challenges, it also simultaneously opens up to more design opportunities to investigate how to stimulate healthy eating routines and behaviors in such a working context.

Moreover, working-age individuals appear to be an increasingly important target group in health research (Huang, Benford, Hendrickx, Treloar, & Blake, 2017). In the global population, working-age individuals (defined as those aged 15 to 64) make up 64.9% of the total (OECD Publishing, 2022). Due to the rapid global expansion of the information-based workforce being conducted via the Internet, computer- and desk-based occupations are estimated to outnumber all other individuals and have been the most valuable assets of a twenty-first-century group because of the high level of productivity and creativity (Drucker, 2011). However, these desk-bound settings are characterized by sedentary work, with the main components associated with unhealthy eating practices and physical inactivity (Kim, Hong, Mok, & Lee, 2012). In the short term, sedentary work regarding unhealthy dietary intake can affect working-age individuals' concentration levels, mood, and working performance (Glympi et al., 2020; Lindseth et al., 2011). In the long term, unhealthy eating patterns can contribute to significantly increasing the risk of obesity, cancers, type 2 diabetes, and a number of mental health problems (Astbury et al., 2019; Simon et al., 2006). On the other hand, coincidentally, the worldwide retirement age has been scheduled to increase between 2020 and 2030, requiring individuals to work longer hours and into their older ages (Glympi et al., 2020). The majority of European nations, including the Netherlands, Germany, Spain, and France, are about to raise their retirement ages from 65 to 67 years old (Finnish Centre for Pensions, n.d.), which implies that working-age individuals will spend more of their lifetimes in the workplace. Thus, it is crucial to take precautionary aimed at preventing the onset of eating-related diseases among working-age individuals by assisting them in developing healthy eating behaviors and managing food intake at work.

Interactive Technologies for Healthy Eating Promotion

Human-computer interaction (HCI) is a field of study focusing on how humans (the users) and computers interact, particularly in designing computer technologies to satisfy various users' needs (Interaction Design Foundation, n.d.). Within the HCI community, public health is an increasingly important topic (Singh et al., 2017), which works to ensure healthy lives as well as promote health and well-being for all ages (World Health Organization, n.d.-a). In recent decades, there has been significant research interest in diet-tracking mobile applications, interventions, and wearable technologies with detecting sensors for health promotion and active lifestyles (Singh et al., 2017).

Dietary-Tracking Mobile Applications Mobile Applications have considerable popularity for intake tracking (Choi, Chung, & Woo, 2021; Ferrara, Kim, Lin, Hua, & Seto, 2019) and are a term for the practice of public health (Adibi, 2015). They allow the collection of dynamic eating-related information, encourage self-monitoring, and deliver suggestions and feedback for health promotion (Fedele, Cushing, Fritz, Amaro, & Ortega, 2017). In relation to goals of weight loss (Bacigalupo et al., 2013;

Burke, Wang, & Sevick, 2011; Stephens & Allen, 2013), general healthcare (Burke, Wang, et al., 2011; Klasnja & Pratt, 2012; Krishna, Boren, & Balas, 2009), and behavior change for personal health (Cole-Lewis & Kershaw, 2010; Fjeldsoe, Marshall, & Miller, 2009), mobile applications have been drawing more and more attention on a global scale (Debon, Coleone, Bellei, & De Marchi, 2019). The dietary-tracking mobile applications, supported by mobile devices (such as mobile phones, tablet computers, and personal digital assistants' devices (Free et al., 2013; Stephens & Allen, 2013)), are developed to monitor food consumption through calorie courting or food diary approaches (Bert, Giacometti, Gualano, & Siliquini, 2014) instead of via detecting sensors. For instance, MyFitnessPal (Under Armour Inc., 2004) is an application with gamification elements that allow users to manually log food intake by pointing their phones at ingredients and recipes. The Fat Secret app (Fatsecret, 2018) mainly focuses on eating planning and helps users lose weight quickly. Also, some Calorie Counter applications, such as MyNetDiary (MyNetDiary, n.d.), were designed to track food intake, analyze food consumption, and guide healthy eating behaviors via personalized dietary tips. Isabel and colleagues (de la Torre Díez, Garcia-Zapirain, López-Coronado, Rodrigues, & del Pozo Vegas, 2017) developed a mobile application that may attempt to raise people's awareness of healthy food choices and recommend practical suggestions for healthy living habits and behaviors accordingly. In general, previous systematic reviews reported that using mobile applications to encourage healthy eating and improve nutrition-related knowledge or behavior guidance can be effective in health promotion (Coughlin et al., 2016).

Interventions Health promotion research has increasingly focused on working context as a potential avenue to place meaningful interventions (World Health Organization, 2008). While the majority of interventions have traditionally concentrated on physical inactivity, recognizing that personal health is a result of the overall energy balance, where eating behaviors contribute alongside physical activity, is crucial (Emilien & Hollis, 2017). Therefore, it becomes imperative to address eating-related interventions to stimulate health promotions in the working context. Besides, evidence showed that effective workplace health-promotion interventions could improve an individual's diet quality and decrease the risk of developing diet-related illnesses (Panchbhaya et al., 2022). More recently, there has been an increase in working-context interventions of healthy eating promotion, typically concentrating on eating-related change, motivational setting, and health knowledge (Allan et al., 2017). Specifically, regarding eating-related change, previous studies (Rigsby, Gropper, & Gropper, 2009; Tate, Wing, & Winett, 2001) suggested that peer support, health competition, as well as financial incentives in worksites could assist individuals in losing weight. Winick and colleagues (Winick, Rothacker, & Norman, 2002) also found that meal replacement regimens (with two portion-controlled servings twice daily) were as effective as structured weight-loss diets for working-age individuals with high-stress working status. Regarding the motivational setting, Scapellato and colleagues (Scapellato et al., 2018) found that motivational counseling, such as identifying eating goals and providing customized advice to individuals, significantly enhances healthy eating habits. Concerning healthy knowledge, several interventions were developed for acquiring healthy eating literacy and information about healthy eating, such as educational course sessions (Aldana et al., 2005), personalized dietary feedback on fat intake (Brug, Steenhuis, van Assema, Glanz, & De Vries, 1999), nutritional wellness counseling (Choy, Chu, Keung, Lim, & Tang, 2017), advisory boards, media campaigns, and videos to increase fruit and vegetable consumption (Sorensen et al., 1998, 1999). In general, these types of interventions may be advantageous due to their convenience and easy accessibility to supporting working-age individuals to undertake motivational awareness and behavior change of healthy eating promotion (Abood, Black, & Feral, 2003).

Sensory Wearable Technologies Wearables, electronic devices situated close to or on the surface of the skin, enable the detection, analysis, and transmission of information such as vital signs and/or ambient data with various sensors (Düking, Achtzehn, Holmberg, & Sperlich, 2018). In the realms of HCI, wearables have been extensively investigated to support and monitor real-time eating behaviors and food intake in daily living contexts (Vu, Lin, Alshurafa, & Xu, 2017). These technologies are favored for their portability, lightweight design, unobtrusiveness, flexibility, aesthetic appeal, robustness, privacy preservation, and ubiquity (Lara & Labrador, 2012; Prioleau, Ii, Member, & Paper, 2017; Zheng et al., 2014). Regarding the purposes of using these technologies, Prioleau and colleagues (Prioleau et al., 2017) summarized different scales, namely recording daily eating moments and duration, planning an eating schedule, measuring eating rate (e.g., chewing and swallowing), as well as monitoring intake quantity and nutritional value. Moreover, wearables offer a preferred means for eating activity recognition and self-tracking with a number of various approaches to bring them into practice, consisting of sensors such as acoustic (Amft, 2010; Amft & Troster, 2006; Bi et al., 2015; Farooq, Fontana, & Sazonov, 2014), image capture (Pouladzadeh, Shirmohammadi, & Al-Maghrabi, 2014; Xu et al., 2013), and motion detection (Amft & Troster, 2006; Dong, Scisco, Wilson, Muth, & Hoover, 2014; Kalantarian, Alshurafa, Le, & Sarrafzadeh, 2015). Specifically, Nishimura and Kuroda (Nishimura & Kuroda, 2008) designed an in-ear-placed wearable microphone that could track eating patterns and provide additional intuitive feedback for users to infer the eating habits in their daily life context. Davis and colleagues (Davies et al., 2021) highlighted the use of wearable cameras with image coding to help young adults make healthy food choices during transport journeys. According to Alshurafa and colleagues (Alshurafa et al., 2014), the swallowing-motion data collected by a wearable system in the form of a necklace allows for the classification of food intake and provides visual feedback to motivate users to develop healthier eating habits over time. Wearable technologies are identified as potential tools, which can enhance an understanding of self-eating patterns and empower individuals to adopt more appropriate eating practices in daily contexts (Lupton, 2014).

1.2 Research Challenges and Opportunities

With an increase in desk-bound occupations, promoting healthy eating behavior in the working context is an important and timely area of interest. Prior studies have extensively shown that employing user-centered design in healthy eating-related research and incorporating playful human-computer interaction are highly correlated with unhealthy eating patterns. A number of theoretical models, such as the Behavior Change Technique (Stawarz & Cox, 2015), have been widely used to support healthy eating behaviors and improve current eating practices. Although previous studies and theoretical models have demonstrated their effectiveness in promoting healthy eating, little research explicitly targets working-age individuals within their work environments for developing and implementing digital interventions and tools. Therefore, the primary motivation behind this doctoral dissertation is to identify research challenges and opportunities by explaining the following question: ***Why is it so challenging to encourage working-age individuals to eat healthier at work?***

The First Reason Concerns the Challenge from the Contextual Perspective - the Dynamic Working Conditions

The Hidden Complexity of Long-Term Care model, developed by Cammer and colleagues (Cammer et al., 2014), identifies numerous contextual features and factors that interact to shape a context that affects care provisions in daily practices. Specifically, these features and factors include Physical Environment (e.g., facility design, room layout, and location), Relationships (i.e., the relationship and social interactions happening within the community setting), and Resources (e.g., physical resources like infrastructure, equipment, and supplies; intangible features like information, training, or time). The complicated context of the worksite arises from unfamiliar physical environments, inadequate resources, ambiguous situations, continual change, and multiple relationships. Addressing the challenge posed by these contextual factors requires a deep understanding of the current working situation and an exploration of the dynamics of eating-working routines to provide meaningful approaches aimed at facilitating healthy eating at work.

The Second Reason Concerns the Challenge from the Individual Perspective – Motivation of Using Self-Reporting Tools

Previous studies revealed that it seemed challenging to promote long-term healthy eating within working routines, as working-age individuals often discontinue the use of digital tools and applications in the working contexts due to overburdened efforts, limited motivations, and low using engagement (Lazar, Koehler, Tanenbaum, & Nguyen, 2015a; Zhu et al., 2008). This highlighted the importance of Self-efficacy (Bandura, 1977), as individuals could only address different challenges (for instance, eating-related behavioral change), when they have a strong belief in their ability to behave effectively. Additionally, according to other studies related to stimulating health care, technological engagement comprises the user's actions, attitudes, goal settings, as well as physical capabilities, and it also manifests as attention, intrinsic interest, curiosity, and motivation (Chapman, 1997; Kappelman, 1995). These constraints limit how the working-age population can promote healthy eating and take advantage of it. Furthermore, a lack of internal motivation, interests, and concentration also presents significant barriers to fostering and sustaining engagement in digital tools for healthy eating promotion, especially in a context with heavy work schedules. To face the challenge related to individual factors, there is a need for digital tools that align with personal abilities and working situations, motivate participation, and sustain engagement.

The Third Reason Concerns the Challenge from the Lack of Creative and Playful Approaches to Stimulate Healthy Eating in the Working Context

Recently, gamified approaches for behavioral change have been applied in various fields (e.g., healthcare, motivating employees, corporative management to promote health-related activity, etcetera) to influence motivation positively and the behavior of users for health-related concepts (Wang, Khoo, Liu, & Divaharan, 2008). Meanwhile, playful features have become common and practical components of smartphone applications, computer programs, and services as they mix information, action, and attraction (Berger & Schrader, 2016). As a result, playful and gamified approaches (i.e., products, services, and digital systems) may meet the need for behavior-specific intervention by turning an intention to eat more sustainably into practice. They could be implemented by using offline technologies for tailored tools and specific target groups (Berger & Schrader, 2016). In this connection, designing technology for health-promotion concepts could be addressed by playful and gamified interventions contributing to enjoyment, engagement, and motivation (Wang et al., 2008).

The Fourth Reason Concerns the Challenge from the Design Approach – Lack Engagement between Potential Users and Designers in a Collaborative Process for Food-Tech Ideation

Evidence has demonstrated that involving potential future users can lead to valuable design outcomes (Farias, Bendor, & van Eekelen, 2022). A key value of involving future users in design is seen as residing in "expertise by experience" (Lushey & Munro, 2015). These users, lacking formal training in design but possessing significant health-related expertise, can bring essential standpoints, skills, knowledge, and their personal experiences of eating to the topics that matter most to them. Their involvement enables designers to gain a keen understanding of the intended user group and draws problem-solving inspirations (Bailey, 2013). In addition, encouraging potential future users to participate in developing food-tech concepts could be beneficial to stimulate their future actions and influence their current motivations and awareness of healthy eating (Bell, 2017). On this ground, proponents of participatory research argue that involving future users in the co-ideation and design process improves the quality and translation of knowledge (Shope, 2020; Skirpan, Cameron, & Yeh, 2018). However, the existing literature indicates a limitation of in-depth studies directly testing how future users and designers collaboratively develop design ideations for food-tech and eating practices in a sequential process. To confront this challenge, it is necessary to delve deeper into the ideation and design process that engages future users in collaborative efforts with designers.

In summary, addressing the abovementioned challenges associated with promoting healthy eating in the workplace necessitates a comprehensive exploration that considers perceptions and perspectives within contextual, individual, playful, and collaborative approaches. In particular, this doctoral dissertation addresses four opportunities for promoting healthy eating at work:

- Developing a comprehensive understanding of the current working context and eating-working routines (this shall be expanded in Chapter 3)
- Assessing an appropriate self-report method for working-age individuals (this shall be expanded in Chapter 4)
- Engaging working-age individuals in reporting intake practices with playful features (this shall be expanded in Chapter 5)

- Establishing a collaborative approach involving users and designers in an ideation process to generate design concepts for food technologies (this shall be expanded in Chapter 6)

1.3 Research Questions

There is a global trend toward increasing efficiency in an effort to meet the intense pressure on working productivity, coupled with time constraints for healthful eating during working hours (Betts et al., 1995; Lappalainen et al., 1997). Specifically, the perceived shortage of time at work has commonly led to reducing time spent on various daily activities, including eating quickly, consuming fast food and convenience foods (e.g., takeaway or pre-packaged foods), as well as doing less physical activity (Welch, McNaughton, Hunter, Hume, & Crawford, 2009). This trend makes the investigation of healthy eating promotion at work more important today and even more in the future. Besides, with a growing group of people having desk-bound occupations, unhealthy eating and eating-related diseases are mounting public health concerns. Therefore, promoting healthy eating in the working context is an important and timely area of interest. Additionally, the shifting of remote working modes makes it even more challenging. In recent years, research and development of digital interventions and tools for healthy eating activities at work have increased dramatically. Although these digital tools and technologies entail possible opportunities, the potential of designing interaction on how to stimulate healthy eating in the working context has not been richly explored.

In this doctoral dissertation, we follow a design research approach to study the role of design in promoting healthy eating among working-age individuals in the working context. Our aim is to develop a comprehensive understanding of the current state-of-the-art in contemporary design and technologies and to explore context-based features that can potentially contribute to healthy eating promotion in the working context. Furthermore, we are interested in investigating awareness support and self-reporting approaches that facilitate working-age individuals to keep up the nutrition-balanced dietary intake and follow a healthy eating routine at work. Finally, we look forward to embracing alternative and imaginative perspectives on future dietary technologies and food forms in stimulating healthy eating.

The overarching research question in this thesis is:

How to design digital tools to promote healthy eating in the working context?

To address our primary research question, we defined four sub-questions:

> ***RQ1:*** *What is the state of the art of digital tools and interventions to promote healthy eating behavior in the working context?*
>
> ***RQ2:*** *What contextual factors should be considered when designing interactive features to promote healthy eating in the working context?*
>
> ***RQ3:*** *In a real-life working context, what self-reported dietary assessment method is an effective tool and how can it be explored with a playful approach?*
>
> ***RQ4:*** *How to envision future roles of innovative food technologies in facilitating healthy eating through a collaborative design approach?*

1.4 Thesis Outline

This dissertation consists of a general introduction (**Chapter 1**) followed by four parts (as shown in Figure 1.1 on Page 21).

PART I | UNDERSTANDING

The first part contains Chapter 2 and Chapter 3.

Chapter 2 investigates ***RQ1*** and provides a scoping overview of the current technology-based healthy eating interventions available for working-age individuals in the working context. We mapped different types of technological interventions and explored an increased understanding of the opportunities for future multidisciplinary research as well as the development of technologies that address healthy eating in the working context.

Chapter 3 addresses ***RQ2*** and presents context exploration research to gather a deeper understanding of the complex working context, working-age individuals' current eating routines and patterns, as well as challenges and needs of existing eating practices within the real-working environment in the Netherlands. The context exploration is carried out by two-fold user studies, namely a contextual inquiry study and a user study with one exploratory design called EAT@WORK.

For the Contextual Inquiry Study, an online questionnaire and semi-structured interviews were conducted to gain the sensitivity of our target users and dynamic eating routines to better understand practical eating challenges and influential factors. Based on the qualitative data analysis, we identified four factors of design opportunities and challenges that researchers and designers may have the potential to influence individuals to positively impact eating routines and behaviors in the working contexts. Four features of digital tools to promote healthy eating in the working context were proposed accordingly. Next, a User Study was conducted to generate potential design opportunities for encouraging healthy eating behaviors and to ensure the relevance of the findings of our Contextual Inquiry Study. We proposed an interactive digital prototype called EAT@WORK with four design features (i.e., *health-related knowledge*, *food choices*, *workouts*, and *social influential factors*) found in the inquiry study. We tested the four digital features via a user study.

PART II | EXPLORING

Guided by the outcomes of the scoping review, we explore the field of interactive digital tools for self-reporting approaches. Part II, addressing ***RQ3***, consists of two studies (Chapter 4 and Chapter 5).

Chapter 4 focuses on investigating the acceptance of two mobile self-reported dietary assessment methods (4-hour Recall vs. Food Record) among 30 working-age individuals in a working context through a within-subject study. In this study, we used a dietary assessment app called Traqq as a research tool, which is developed by researchers from Wageningen University in the Netherlands. By comparing the two reporting methods among working-age individuals in a real-life working setting, we aimed to explore the role of dietary reporting tools at work and provide design insights into how this self-reporting tool can affect awareness and routines of healthy eating in the working context.

Inspired by the findings of the within-subject study with Traqq, **Chapter 5** presents a design called NutriColoring, a self-reported toolkit designed to leverage the Doodling method on sketches to report and reflect on everyday intake in a real-life working context. We explored the use of a playful Doodling solution that can support the practice of dietary self-reporting through a field study. We draw design insights on relating nutritional elements with various colors and mapping playful elements to a self-reported toolkit for exploring the role of Doodling-based and

color-based reporting approaches in facilitating awareness of healthy intake and triggering self-reported activity in the working context.

PART III | ENVISIONING

The third part of this thesis looks forward to a collaborative ideation approach for future food technologies in facilitating eating behaviors and exploring design innovations (***RQ4***).

By means of a creation workshop, **Chapter 6** presents the development of a Collaborative Ideation Approach as a participatory approach to exemplify how fictional narratives can trigger imaginations about future technologies for eating practices. Through this approach exemplar, 97 fictional narratives and 62 provocative design concepts that provide an alternative reality and imaginative perspectives on future eating experiences, food forms, and food technologies were proposed. The result opens discussions of how provocative narratives could inspire designers and researchers to explore design concepts for Human-Food Interaction heuristics in a co-ideation manner.

PART IV | REFLECTING

The last part of this thesis draws together our conclusions, reflections, as well as implications. **Chapter 7** concludes the formulated answers to our research questions, reports limitations and future works, and summarizes research contributions. **Chapter 8** endeavors to present the implications and reflections gleaned from this research journey to help inspire future design and research processes when promoting healthy eating at work.

1.5 Main Contributions

This thesis contains a series of explorations investigating the nature of healthy eating promotion within the working context. It provided insights to support future researchers in designing interactive tools and interventions that could positively influence working-age individuals eating practices. This thesis makes the following contributions that could be interesting for several domains of knowledge:

- It contributes insights for researchers and designers by offering a scoping review of existing dietary technologies and interventions that have the potential to positively impact individuals' eating practices and facilitate the development of healthier eating habits.

- It provides healthy-eating-related design research, context-specific knowledge, and insights on what might contribute to healthy eating behaviors for working-age individuals in their daily working context. It presents practical examples of tools (such as the EAT@WORK app, Traqq app, and NutriColoring toolkit) designed to assist individuals in adopting healthier eating patterns from contextual, self-report, and playful perspectives.

- It offers designers a series of design implications, reflections, and approaches to help inform future design and research processes when working with and for healthy eating promotion at work.

- It also enlightens the potential benefits of engaging future users in collaborative ideation with designers. This process can enhance user-centric design, cater to users' needs, and glean valuable insights from their eating experiences to develop and refine design concepts for food technologies.

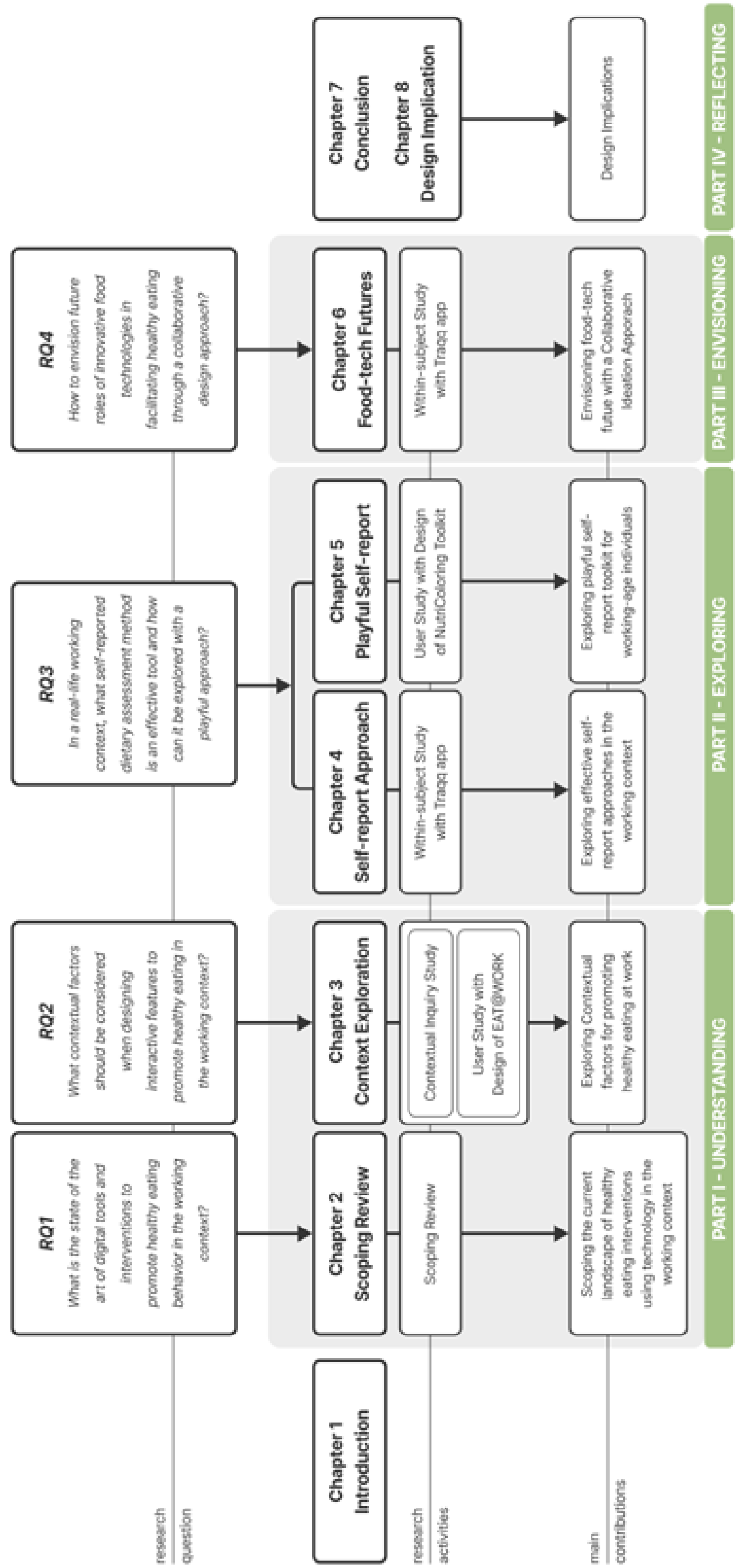

Figure 1.1 A visualization of the thesis outline.

PART I | UNDERSTANDING

In the introduction, we have seen that designing new tools and techniques, with the goal of motivating individuals to take responsibility for their health on improving eating practices and intake, offers opportunities to nudge people towards a healthier lifestyle. This is a crucial topic of interest for both designers and researchers. However, given that individuals spend approximately one-third of their waking time in their working contexts, there needs much scope for considering the development of health promotion tools tailored to the working context and targeted at working-age individuals.

In this part, we conducted a two-fold investigation. First, we conduct a scoping review in Chapter 2 to understand existing technologies and tools that have already been developed to promote healthy eating at work. Second, in Chapter 3, we conducted a user-centered inquiry study involving qualitative questionnaires and semi-structured interviews with an aim of gaining a comprehensive understanding of the contextual factors within the working context that impact individuals' eating practices. Based on these insights, the EAT@WORK app was designed. Furthermore, we also discuss several design implications stemming from our research findings, which have motivated us to explore further research directions in the subsequent chapters.

2 Scoping Review

This chapter is a reproduction of the paper published as:

Sibo Pan, Xipei Ren, Steven Vos, and Aarnout Brombacher. (2021). **Digital Tools to Promote Healthy Eating for Working-Age Individuals: A Scoping Review.** In *Proceedings of the Ninth International Symposium of Chinese CHI* (pp. 1-8). ACM.

Abstract

In this chapter, we scope the existing digital tools for promoting healthy eating behaviors in the working context among working-age individuals and identify research gaps for future design opportunities. A scoping review was conducted in three databases: the Association for Computing Machinery (ACM) digital library, the interdisciplinary library Scopus, and the PubMed database. Initially, 2098 papers were identified, of which 16 papers were included in the final analysis. These 16 papers were published in 15 various conference proceedings or journals between 2010 and 2021, and mainly focused on tracking eating moments and promoting healthy food intake. Our findings showed that four types of digital tools for healthy eating promotion were commonly used, including mobile applications, wearables, service, and multicomponent (i.e., a combination of mobile apps and wearables). Moreover, we found that current digital tools are made small using a range of existing working infrastructures. Future design research could focus on personalized, interactive, and playful digital tools in HCI with behavior change techniques and user-centered approaches to promote healthy eating behaviors in daily work routines. We concluded by discussing design and research opportunities for future technology. The objectives of this chapter are:

- To understand state-of-the-art of existing digital tools with technologies that are applied to promoting healthy eating during working hours.
- To identify potential design and research opportunities for future health-promoting tools that support healthy eating practices among working-age individuals.

2.1 Introduction

A healthy eating behavior commonly seems to be a critical component that paves the way for individuals' vitality and health. According to the World Health Organization, an unhealthy diet is a major risk factor for a range of non-communicable diseases, including obesity, diabetes, and other conditions linked to cancer (Branca, Nikogosian, & Lobstein, 2007). Particularly, populations like working-age individuals, who are more susceptible to obesity and other chronic diseases, need to practice appropriate eating habits and routines more frequently in their daily lives (J. Chung et al., 2017). In recent decades, technology-based interventions for health promotion in the workplace have been developed to encourage people to adopt health-stimulating behaviors, including a healthy diet (Cahalin et al., 2015). Since people spend two-thirds of the daily waking hours on their full-time jobs (Allan et al., 2017), worksites potentially offer an important occasion and opportunity for influencing personal eating patterns.

Recent studies related to automatic dietary monitoring appraoches and human-food interactions have shown that digital technologies present an opportunity to measure actual eating-related behaviors (Amft, 2008; Bi et al., 2017; He et al., 2020; Vu et al., 2017). Eating-linked non-medical digital technologies are generally effective in detecting eating time, weight management, and healthy food consumption (fruits and vegetables) (Quintiliani, Poulsen, & Sorensen, 2010). These digital technologies are designed as mobile applications (e.g., MyFitnessPal (Evans, 2017), Fitocracy Macros (Higgins, 2016)) and wearable devices (e.g., motion detection during intake (Junker, Amft, Lukowicz, & Tröster, 2008), chewing (Amft, Stäger, Lukowicz, & Tröster, 2005), swallowing detection (Amft & Troster, 2006) , and digital photography (Almaghrabi, Villalobos, Pouladzadeh, & Shirmohammadi, 2012; Martin et al., 2014)).

According to several systematic reviews, interventions (e.g., web-based, educational approaches, feedback, etcetera) targeting both eating behavior and physical activity have an impact on assisting with personal weight management (Anderson et al., 2009; Maes et al., 2012; Verweij, Coffeng, van Mechelen, & Proper, 2011). Similarly, several reviews and studies have discovered that worksite eating promotion tools could be leveraged to reduce the chance of developing obesity and overweight due to sedentary working hours (Benedict & Arterburn, 2008; Upadhyaya, Sharma, Pompeii, Sianez, & Morgan, 2020) as well as aiding the work-caused eating disorders (Siegel & Sawyer, 2019). Additionally, it was revealed in several other reviews that applying behavior theories for reminding healthy eating during working hours (Close, Lytle, Chen, & Viera, 2018) and providing feedback based on personal health assessments (Soler et al., 2010) could improve the effectiveness of worksite health-promoting interventions.

Few review studies are specifically focused on understanding technologies and designs for healthy eating during working hours. In this present chapter, we reviewed recent digital technologies to assess intake or promote occupational healthy eating behaviors. The scoping review summarized research from 2010 to June 2021 on digital technology for non-medical eating purposes. Rather than focusing on the outcomes of the designs and technologies, this review aims to provide an overview of the design considerations for healthy eating technologies. Based on this scoping review, we hope to identify the research gaps in the daily eating promotion and design opportunities of digital tools using technology for the working context. In particular, we aim to:

1) understand how those technologies and designs were applied to promoting occupational healthy eating;
2) identify design opportunities for future health-promoting technologies that support healthy eating practices among working-age individuals.

2.2 Methods

2.2.1 Search and Selecetion

The scoping literature review in this chapter was guided and conducted according to a methodological framework (Arksey & O'Malley, 2005), involving 1) identifying the research question, 2) identifying relevant published papers, 3) selecting paper, 4) charting the data, and 5) collating, summarizing and reporting the results. The search included full-text research papers in the English language published in peer-reviewed scientific conference proceedings or journals in the Association for Computing Machinery (ACM) digital library, the interdisciplinary library Scopus, and the PubMed database. All articles were searched for designs or technologies that aimed at promoting intake assessment and healthy eating behaviors partly or exclusively during working hours. The following search keywords were used: ("human-food interaction" OR "health informatics" OR "digital tool" OR "digital technology" OR "wearable sensor") AND ("eating" OR "diet") AND ("office" OR "workplace" OR "working hour"). We limited the publication dates of the papers to the period between 2010 and June 2021.

Furthermore, only papers that applied digital technologies to promote healthy eating behavior in general working-age populations for non-therapeutic purposes were taken into consideration and selected for further analysis. The work-age populations are the adults who do not have eating-related diseases and exhibit eating behaviors in a working context (i.e., office). The searched papers were reviewed for eligibility based on the following three excluding criteria:

1) Paper has therapeutic purposes or target patient populations;
2) Paper describes the designs or technologies for special user groups, such as children, family members, students, or the elderly;

3) Food serves as a medium for presenting health-related information instead of encouraging healthy eating itself.

2.2.2 Procedure and Data Analysis

The selection process of our study was done with the following four main steps: database search, title and abstract screening, full-text screening, and snowball search. First, papers published between 2010 and June 2021 were searched in the ACM digital library, Scopus, and PubMed. Second, the titles and abstracts were screened by two independent authors from the research team based on the selected inclusion and exclusion criteria. Third, a snowballing procedure in the reference lists of the selected papers and the citations was manually performed to identify additional papers (Wohlin, 2014). Twenty-one extra papers were included as additional eligible papers. Fourth, three authors from the research team performed a full-text screening of the selected papers. Consensus was reached after deliberating discrepancies. Eventually, sixteen eligible papers were included in our final review for data synthesis. These papers were extracted in terms of publication data, objectives, theoretical underpinning, using context, and types of design and technology. The qualitative data was analyzed by two independent coders, following the thematic analysis procedure (Thomas & Harden, 2008). All analyzed results were discussed and agreed upon among research team members. Disagreements were resolved via deliberations.

2.3 Results

2.3.1 Study Selecetion

An overview of the selection process in the various stages is visualized in Figure 2.1.

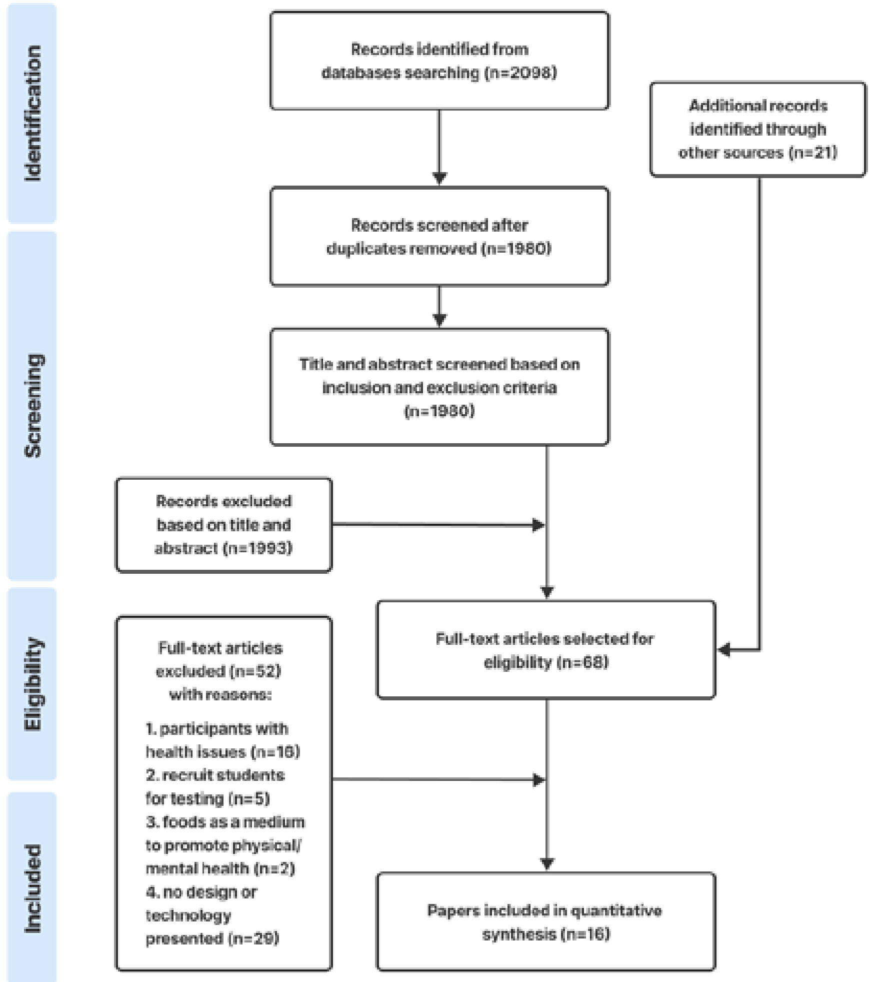

Figure 2.1 Flowchart of paper selection process following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline.

Table 2.1 Overview of selected papers.

	Reference	Sample Size	Design Name/ Technology Type	Description	Objective
1	(Alinia et al. 2011)	124	Fruit basket intervention with free fruits in worksite	By increasing fruit availability and accessibility in the worksite to encourage daily fruit intake	Increases fruits consumption during working hours
2	(Bedri, Verlekar, Thomaz, Avva, & Starner, 2015)	20	Outer-ear interface system	Detect eating activities automatically by measuring deformations in the ear canal walls due to mastication activity	Help to identify eating moments automatically
3	(Bi et al., 2015)	53	AutoDietary	A wearable system to recognize food types by monitoring eating process and provide tailored suggestions	Monitor daily food intake of an individual precisely and conveniently
4	(J. Chung et al., 2017)	10	GlasSense	Monitoring patterns of food and facial activities through load cells embedded a pair of glasses	Help to identify eating moments automatically
5	(Dong et al., 2014)	43	Watch-like device	A watch-like configuration of sensors to continuously track wrist motions and automatically detect periods of eating	Help to identify eating moments automatically throughout the day
6	(Hartwell et al., 2019)	233	FoodSmart app	Enable informed consumer food choice, and takes individual preferences as well as food product specifications into account	Provide tailored feedback and appropriate format to enable informed food choice out of home
7	(Lassen et al., 2012)	27	A Canteen Take Away (CTA) concept	Provide free CTA and ready-to-heat meal to help employees build a healthy eating behavior during working hours	Promote healthy eating habits among employees

	Reference	Sample Size	Design Name/ Technology Type	Description	Objective
8	(Matsushita & Kaneshima, 2019)	3+1	Motion sensing eyewear device	A motion sensing device attached to eyeglasses for monitoring daily activity	Recognize daily activities (wating, working and other activities)
9	(Rahman et al., 2014)	14	BodyBeat	A novel mobile sensing system for capturing and recognizing a diverse range of non-speech body sounds in real-life scenarios	Recognize non-speech body sounds (such as food intake, breath) by capturing subtle body vibrations
10	(Rahman, Czerwinski, Gilad-Bachrach, & Johns, 2016)	8	Wearable sensing system	Train detector via machine leaning with personal eating data to predict about-to-eat moments and trigger healthy eating interventions prior to actual eating events	Predict "about-to-eat" moments and "time until the next eating event"
11	(Sysoeva, Zusik, & Symonenko, 2017a)	8	User-friendly communication channel	Scan code from food product and provide information about food items via text and voice communication	Know food batter and have a good food choice
12	(Thomaz, Parnami, Essa, & Abowd, 2013)	5	First-person camera on smartphone application	Phone-based application that takes photos automatically every 30 second to identify eating moments in first-person point-of-view images	Recognize eating moments in real-world settings
13	(Thomaz, Essa, & Abowd, 2015)	21	Automated food intake monitoring system	Eating moment detection with wrist-mounted inertial sensor from a smartwatch	Identify when eating moments take place and recognize eating or non-eating time
14	(Thomaz, Zhang, Essa, & Abowd, 2015)	20	Sensor system with acoustic sensor	Eating activities are inferred from ambient sounds captured with a wrist-mounted device	Identify meal eating moments

	Reference	Sample Size	Design Name/ Technology Type	Description	Objective
15	(Zhang & Amft, 2018)	10	Electromyography-monitoring eyeglasses	Identify eating moments in continuous wearable sensor data	Help to identify eating moments automatically
16	(Zhang et al., 2021)	53	Gamification app: DMCoach+	A personal health gamification system to promote occupational health conditions with goal setting and remote coach	Prevent occupational eating-related health issues

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, & Group, 2009) was used to guide the selection process. Our initial search identified 2098 papers from the ACM library, Scopus, and PubMed databases. After removing 118 duplicates, 1980 relevant papers remained. The titles and abstracts of these papers were screened based on the selection criteria, after which 47 papers were selected as eligibility. The additional 21 articles were retrieved from the reference list and added to the review list. Of these, papers were excluded (i) where participants were selected because of obesity or other health-related issues (n = 16), (ii) where peers were recruited to test prototypes (n = 5), (iii) where foods were used to promote physical activities or mental pleasure (n = 2), or (iv) where no digital tools or technology was presented (n = 29).

Sixteen papers are included in the final review list (shown in Table 2.1). Five were full-text conference articles, four were short conference articles, and seven were full-text journal articles. These papers were published in 15 various conference proceedings or journals between 2010 and June 2021. These papers were published by thirteen different first authors from various continents.

2.3.2 Characteristics of the Included Papers

Objective Among the 16 included papers, ten papers presented digital tools and designs aimed at identifying eating moments in real-life settings (Bedri et al., 2015; J. Chung et al., 2017; Dong et al., 2014; Matsushita & Kaneshima, 2019; Rahman et al., 2014, 2016; Thomaz, Essa, et al., 2015; Thomaz et al., 2013; Thomaz, Zhang, et al., 2015; Zhang & Amft, 2018), while the other papers focused on improving eating behaviors and food choice (Alinia et al., 2011; Bi et al., 2015; Hartwell et al., 2019; Lassen et al., 2012; Sysoeva et al., 2017a; Zhang et al., 2021) (as shown in Table 2.2). Specifically, regarding the ten papers on eating moments identification, seven (Bedri et al., 2015; J. Chung et al., 2017; Dong et al., 2014; Thomaz, Essa, et al., 2015; Thomaz et al., 2013; Thomaz, Zhang, et al., 2015; Zhang & Amft, 2018) utilized digital tools to automatically monitor daily eating time and duration. One paper (Rahman et al., 2016) further predicts following eating events for users after monitoring. In another two papers (Matsushita & Kaneshima, 2019; Rahman et al., 2014), eating moments were measured by distinguishing eating activities from other daily activities (such as working, speaking, and walking). Regarding the six papers on improving eating patterns and food choices, two studies (Hartwell et al., 2019; Sysoeva et al., 2017a) involved encouraging healthy food choices by scanning codes to obtain interactive food-related information. Two studies have promoted healthy eating habits at work (Lassen et al., 2012; Zhang et al., 2021). One study (Alinia et al., 2011) focused on increasing fruit consumption in the work setting, and another study (Bi et al., 2015) used digital technology to measure food intake.

Table 2.2 Objectives in the included technologies and designs.

Objectives	Included papers
Identifying eating moment	(Bedri et al., 2015; J. Chung et al., 2017; Dong et al., 2014; Matsushita & Kaneshima, 2019; Rahman et al., 2014, 2016; Thomaz, Essa, et al., 2015; Thomaz et al., 2013; Thomaz, Zhang, et al., 2015; Zhang & Amft, 2018)
Improving eating behavior and promoting healthy food choice	(Alinia et al., 2011; Bi et al., 2015; Hartwell et al., 2019; Lassen et al., 2012; Sysoeva et al., 2017a; Zhang et al., 2021)

Theoretical Underpinning As shown in Table 2.3, eleven of the included papers did provide various approaches for encouraging individuals to gain healthy eating patterns. However, the use of behavior change techniques (BCT) with digital technologies has only been specifically mentioned in three studies — two studies (Bi et al., 2015; Hartwell et al., 2019) used a digital tool with tailored feedback as BCT, while one study (Zhang et al., 2021) supported the user to set diet-related health goals and created the social support to promote healthy eating behaviors. Besides, the Activity recognition model was used in five studies (Bedri et al., 2015; Bi et al., 2015; Dong et al., 2014; Thomaz, Essa, et al., 2015; Thomaz, Zhang, et al., 2015) to sperate eating moments from other everyday tasks. Six other papers based on their technologies and designs on, respectively, Monitoring of ingestive behavior (J. Chung et al., 2017), Personal nutrition planner (Alinia et al., 2011), Machine learning model (Rahman et al., 2016), Human-food interaction (Sysoeva et al., 2017a), Social gamification system (Zhang et al., 2021), and Dietary self-monitoring (Thomaz, Zhang, et al., 2015).

Design Approach According to the characteristic description of the 16 included papers, several types of design approaches were adopted, namely user-centered approach, technology-driven approach, and context-driven approach (as shown in Table 2.4). On the one hand, six included papers purely used one design approach. Specifically, two papers (Hartwell et al., 2019; Sysoeva et al., 2017a) developed design based on qualitative research and mainly focused on user-centered applications to encourage healthy food choices, while four (Bedri et al., 2015; J. Chung et al., 2017; Rahman et al., 2014; Thomaz, Zhang, et al., 2015) presented the setup and algorithm of technologies for intake detection. On the other hand, the rest ten included papers used mixed two design approaches. In particular, among these ten papers, six (Bi et al., 2015; Dong et al., 2014; Matsushita & Kaneshima, 2019; Thomaz, Essa, et al., 2015; Thomaz et al., 2013; Zhang & Amft, 2018) mixed technology- and context-driven approaches, since the reported technologies were used in real-life daily settings (e.g., weekdays) instead lab experiment. Two (Alinia et al., 2011; Lassen et al., 2012) combined user-centered and context-driven approaches because the designs were mentioned for users'

Table 2.3 Theoretical underpinning used in the paper included in the analysis.

Theoretical underpinning	Included papers
Behavior change technique (tailored feedback, goal setting, and social support)	(Bi et al., 2015; Hartwell et al., 2019; Zhang et al., 2021)
Human-food interaction	(Sysoeva et al., 2017a)
Monitoring of ingestive behavior	(J. Chung et al., 2017)
Machine learning model	(Rahman et al., 2016)
Personal nutrition planner	(Alinia et al., 2011)
Recognition model	(Bedri et al., 2015; Bi et al., 2015; Dong et al., 2014; Thomaz, Essa, et al., 2015; Thomaz, Zhang, et al., 2015)
Social gamification system	(Zhang et al., 2021)
Dietary self-monitoring	(Thomaz, Zhang, et al., 2015)
Not specified	(Lassen et al., 2012; Matsushita & Kaneshima, 2019; Rahman et al., 2014; Thomaz et al., 2013; Zhang & Amft, 2018)

healthy food intake in the working context. In addition, the other two papers used user-centered and tech-driven approaches. One of the two (Rahman et al., 2016) technically detected users' daily intake and provided personalized suggestions at the meanwhile, while another one (Zhang et al., 2021) merged technology with gamification to increase users' engagement in intake detection during working hours.

Table 2.4 Design approaches mentioned in the included papers.

Approach	Included papers
User-centered approach	(Alinia et al., 2011; Hartwell et al., 2019; Lassen et al., 2012; Rahman et al., 2016; Sysoeva et al., 2017a; Zhang et al., 2021)
Technology-driven approach	(Bedri et al., 2015; Bi et al., 2015; J. Chung et al., 2017; Dong et al., 2014; Matsushita & Kaneshima, 2019; Rahman et al., 2014, 2016; Thomaz, Essa, et al., 2015; Thomaz et al., 2013; Thomaz, Zhang, et al., 2015; Zhang et al., 2021; Zhang & Amft, 2018)
Context-driven approach	(Alinia et al., 2011; Bi et al., 2015; Dong et al., 2014; Lassen et al., 2012; Matsushita & Kaneshima, 2019; Thomaz, Essa, et al., 2015; Thomaz et al., 2013; Zhang & Amft, 2018)

Table 2.5 Types and examples of included technologies and designs.

<table>
<tr><th>Types</th><th>Included papers</th><th>Example</th></tr>
<tr><td>Mobile application</td><td>(Hartwell et al., 2019; Sysoeva et al., 2017a; Zhang et al., 2021)</td><td>
(C. Zhang et al., 2021)</td></tr>
<tr><td>Wearable</td><td>(Bedri et al., 2015; J. Chung et al., 2017; Dong et al., 2014; Matsushita & Kaneshima, 2019; Rahman et al., 2014; Thomaz, Essa, et al., 2015; Thomaz, Zhang, et al., 2015; Zhang & Amft, 2018)</td><td>
(Zhang & Amft, 2018); (Dong et al., 2014)</td></tr>
<tr><td>Office service</td><td>(Alinia et al., 2011; Lassen et al., 2012)</td><td>/</td></tr>
<tr><td>Multicomponent</td><td>(Bi et al., 2015; Rahman et al., 2016; Thomaz et al., 2013)</td><td>
(Rahman et al., 2016); (Thomaz et al., 2013)</td></tr>
</table>

2.3.3 Type of Technology and Design

As shown in Table 2.5, several different types of technologies for healthy eating promotion during working hours were presented in the 16 included papers. The digital tools included mobile applications (Hartwell et al., 2019; Sysoeva et al., 2017a; Zhang et al., 2021), wearable devices (Bedri et al., 2015; J. Chung et al., 2017; Dong et al., 2014; Matsushita & Kaneshima, 2019; Rahman et al., 2014; Thomaz, Essa, et al., 2015; Thomaz, Zhang, et al., 2015; Zhang & Amft, 2018), office service (Alinia et al., 2011; Lassen et al., 2012), and multicomponent (i.e., combination between app and wearable) (Bi et al., 2015; Rahman et al., 2016; Thomaz et al., 2013).

Mobile Application Three included papers (18.75%) designed mobile-based applications as a digital tool for healthy eating promotion. The main components of this type of technology were the interaction between users and their intake as well as the tailored guidance for individuals' intake quality (such as goal setting, real-time interaction with food consumption, feedback, and advice). In addition to the specific components, two applications (Hartwell et al., 2019; Sysoeva et al., 2017a) focused on encouraging healthy food choices via scanning the code on food itself or food-related objects (e.g., the package or the table). By doing so, users can have a good understanding of nutrient ingredients and gain tailored suggestions. Moreover, one paper (Zhang et al., 2021) focused on promoting occupational health via gamification and e-coaching. This mobile application supported users to set personal health goals and motivated users to achieve their goals via social competitions. By combining eating and physical activity, this application aims to help users gain healthy habits in daily life.

Wearable Eight papers (50%) presented sensors-based wearables. Three of these studies used wrist-worn wearables (Dong et al., 2014; Thomaz, Essa, et al., 2015; Thomaz, Zhang, et al., 2015), three used eye-worn wearables (J. Chung et al., 2017; Matsushita & Kaneshima, 2019; Zhang & Amft, 2018), one (Bedri et al., 2015) used an ear-worn wearable, and one (Rahman et al., 2014) used a neck-worn wearable. These eight papers aimed to measure eating time, while two of them (Matsushita & Kaneshima, 2019; Thomaz, Essa, et al., 2015) also focused on detecting eating duration, and one (Dong et al., 2014) on detecting eating frequency. In addition, each wearable depends on various sensors and measuring approaches. Specifically, six papers presented the means of detecting body movements, i.e., jaw movements (Bedri et al., 2015), chewing (Zhang & Amft, 2018), facial muscle activity and head motion (J. Chung et al., 2017; Matsushita & Kaneshima, 2019), as well as wrist motion and gesture (Dong et al., 2014; Thomaz, Essa, et al., 2015). While eating activity was inferred from ambient sounds captured with acoustic sensors from the other two papers (Rahman et al., 2014; R. Zhang & Amft, 2018).

Office Service Two of the 16 papers (12.5%) provided service design to promote healthy eating in the working context. These two papers provided healthy food as the key component to improving eating habits and employees' health. In one study (Alinia et al., 2011), fruit accessibility in the workplace was designed to encourage more healthy fruits and vegetables intake during working hours. Another study (Lassen et al., 2012) provided ready-made takeaway meals with well-nutrient composition in the office canteen to encourage healthy food choices among employees.

Multicomponent Three included papers (18.75%) were designed with multiple digital tools. This multicomponent approach was identified as a combination between wearables and mobile applications. Two papers developed wearables for intake measurements and then used a mobile application to provide food patterns, eating suggestions, and feedback. Specifically, one paper (Bi et al., 2015) presented a digital system that recognized food types by monitoring the

eating process via an acoustic sensor and provided meal recognition accordingly to the user. In another paper (Rahman et al., 2016), a machine learning algorithm was trained with user's eating data to predict about-to-eat moments to promote healthy eating habits. Another paper (Thomaz et al., 2013) designed a wearable smartphone that could be worn in front of the body and capture daily routines and activities by images.

2.4 Discussion

The scoping review was set out to comprehensively understand digital tools with technology for occupational health promotion. Through a literature search in the ACM digital library, the interdisciplinary library Scopus, and the PubMed database, we identified and analyzed 16 included papers published between 2010 and June 2021. This chapter provides an overview of paper characteristics, including using digital technology and design objectives, theoretical underpinning, using contexts, and types of digital technology for healthy eating promotion during working hours. The narrative analysis revealed two important gaps in current research as follows.

First, two most common objectives of recent research were detecting daily eating moments and encouraging healthy food choices. Few papers aimed at behavior change purposes. Of the 16 included papers in this review, only three papers mentioned the behavior change technique (BTC). Two papers (Hartwell et al., 2019; Sysoeva et al., 2017a) developed user feedback mechanisms after measuring nutrients in foods using digital tools. One study (Zhang et al., 2021) supported the user in setting diet-related health goals and creating social support to promote healthy eating behaviors in the workplace. Other included papers presented dietary self-monitoring, personal nutrition planning, and machine learning modeling as techniques. Moreover, five included papers did not specify any techniques. The need of using BCTs in healthy eating was in line with previous work. For instance, the application of persuasive techniques could effectively increase users' awareness of specific health behaviors (Orji & Moffatt, 2018). Supporting goal-setting and facilitating goal-achieving activities could help shape positive attitudes toward healthy lifestyles (West et al., 2017). And human-computer interaction (HCI) for health also needs to embed BCTs to support long-term behavior change (Stawarz & Cox, 2015). Therefore, in future design studies, we suggest researchers create digital tools for healthy eating promotion in the working context by adopting various BCTs (e.g., tailored feedback, goal setting, rewards, social support, persuasion, self-reflection) (Cheng Chia, Anderson, & McLean, 2019).

Second, we found that the technology and design formats could be integrated into existing working infrastructures to increase user engagement. Only one paper employed an office basket to supply free fruits in the workplace, while other papers mainly focused on personal technologies to promote healthy eating during working hours. According to prior studies, working-age individuals may consider the wearable sensors too obtrusive to use in a working context for the long term (Neil et al., 2013) and may abandon using mobile applications because of too much effort required against their work schedules and routines (Lazar et al., 2015a). Besides, some of the papers included in this scoping review also emphasized easy and frequent use by reducing the complexity of technology or design (Bi et al., 2015; Hartwell et al., 2019). This is in line with a number of existing technologies and design concepts. For instance, reducing prices on nutritious snacks in office vending machines could be beneficial to increase healthy food choices (French et al., 2001). Moreover, using existing objects might reduce the additional time requirement of users, which leads to an essential design opportunity in the health-promotion research field (Patrick et al., 2016). Hence, in future research, it could be an opportunity to examine whether integrating technology and design into working infrastructure will motivate people to use digital tools.

In addition, several included papers in this scoping review detected eating moments, frequency, and duration with digital tools. Some also focused on distinguishing eating time from other daily activities (e.g., working and talking). However, few digital tools have been specified to promote the dynamics between working and eating routines. In future research, first, promoting healthy eating in working routines could be a design opportunity. Maintained routines could help users balance the tension between working and eating in a real-life context (Spahn et al., 2010; West et al., 2017). Second, one included paper (Zhang et al., 2021) used a gamification approach, and another study (Sysoeva et al., 2017a) provided interactive communication to users as an efficient method to promote healthy eating. This is in line with other studies within the HCI field, showing that playful tools could contribute to future eating-linked technology and help users engage in the technology (Bertran, Wilde, Berezvay, & Isbister, 2019; Tondello, 2016). Thus, future design research could use playful human-computer interaction and gamification between eating and users to promote healthy eating in a working context. Third, most of the included papers used a technology-driven approach to develop digital tools in the working context, while few papers focused on a user-centered approach. Thus, future digital tools could involve user-centered design in healthy eating-related research.

The scoping review in this chapter had some limitations. First, by restricting our search from three databases, we might have excluded some relevant publications. Although we aimed to review technology and design for healthy eating promotion in the working context, a large number of papers addressed therapy-oriented tools or targeted at children and the elderly. Hence, we only included 16 papers in our final analysis. Second, three of the sixteen included papers specifically mentioned the type of keywords "employee" and "workplace", while the rest papers were assumed by the reviewers since the papers described working context and recruited working-age individuals as their participants. Third, this is a scoping review, which aims to qualitatively understand current digital tools and design opportunities for occupational healthy eating promotion without quantitative outcome analysis. Thus, in this review, digital tools are mainly linked to detecting eating time, eating frequency, eating duration, healthy food choices, and healthy eating habits. The technologies and designs focused on nutrition intake measurements were not explicitly presented in the included papers.

2.5 Conclusion

This chapter aims to overview technologies and designs for promoting occupational healthy eating and identify design opportunities for future health-promoting digital tools that support healthy eating practices during working hours. The 16 included papers were published between 2010 and June 2021 in the fields of digital health, nutrition, human computation, wearables, sensors and mobile technology, and interactive systems. Our review results revealed that (1) current technologies and designs made limited use of existing working infrastructures. (2) Few digital tools for occupational healthy eating promotion addressed behavior change techniques in the developing process. Moreover, we suggested that future design research could (1) investigate interactive and playful digital tools with user-centered approach and behavior change techniques (e.g., rewards, persuasion, and self-reflection) to promote healthy eating behaviors and routines during working hours; (2) involve intake measurements into occupational healthy eating promotion, and more technologies and designs could be evaluated to show the effectiveness of outcomes.

3

Context Exploration

This chapter is a reproduction of the papers published as:

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Abstract

This chapter presents a research approach that includes a user-centered contextual inquiry and a within-subject user study. (1) A contextual inquiry study was conducted using mixed methods with an online questionnaire and a semi-structured interview. This study aimed to understand knowledge workers' eating experiences and identify design opportunities and application strategies of digital tools to improve current eating practices. The responses to the questionnaire from 54 Dutch working-age individuals revealed their concerns over productivity, health and nutrition, energy support, and well-being, which could be decisive in shaping their eating routines at work. Furthermore, the results of 12 interview sessions recommended a set of expected digital features to support healthy eating at work, including health knowledge access, goal setting and self-tracking, technology-assisted health programs, and social support.

(2) Inspired by the user insights of contextual inquiry, a mHealth app called EAT@WORK was designed to support working-age individuals in the Netherlands in developing healthy eating behaviors at work. Based on semi-structured interviews with 12 office workers from a variety of occupations, we synthesized four key features for EAT@WORK, including supporting easy access to relevant knowledge, assisting goal setting, integrating with health programs, and facilitating peer support. The user acceptance of EAT@WORK was examined through a within-subject study with 14 office workers, followed by a qualitative study on the applicability of app features to different working contexts. Quantitative results showed that EAT@WORK was experienced more useful than a benchmark app ($p < 0.01$), and EAT@WORK was also perceived easier to use than the benchmark app ($p < 0.01$). The qualitative analysis suggested that the goal assistant feature could be valuable for different working contexts, while the integrated health program was considered more suitable for office work than telework. The social and knowledge support were expected to be on-demand features that should loosely be bonded with the working contexts. We concluded by discussing the design implications for the future development of such mHealth technologies to promote healthy eating routines among working-age individuals.
The objectives of this chapter are:

- To understand contextual considerations related to eating practices among working-age individuals and derive possible features from applying mHealth technologies to the workday eating routines.
- To develop the EAT@WORK prototype and test its acceptance from a user-centered perspective.

3.1 Introduction

The prevalent health problems related to eating behaviors, such as cardiovascular diseases, cancer, type 2 diabetes, and suboptimal conditions linked to obesity, increasingly affect the working-age population (World Health Organization, 2003). Evidence showed that these eating-related issues may result in increased absence rates and decreased productivity at work (Berghöfer et al., 2008; Van Duijvenbode, Hoozemans, Van Poppel, & Proper, 2009). Therefore, to prevent eating-related diseases and to promote healthy eating behaviors at work may not only have economic benefits (Proper et al., 2004) but also provide improvement in individuals' health and mental well-being (Maes et al., 2012).

A variety of different factors can influence healthy eating behaviors in daily contexts, such as socioeconomic status, the accessibility of healthy foods, self-efficacy for healthy eating, and daily working routines (Brug, 2008; Swan, Bouwman, Hiddink, Aarts, & Koelen, 2015). Previous research showed that work routines offer good settings to apply healthy eating interventions (Brug, 2008). Many interventions have been introduced into working contexts, and their effectiveness in promoting healthy eating has been widely evaluated. For instance, Campbell and colleagues (Campbell et al., 2002) tailored a health program specifically for female workers, which was proved as a practical approach to increasing fruit and vegetable consumption. Park and colleagues (S. Park et al., 2017) researched cultural and social support for food choices and eating patterns among South Korean employees. Their study results suggested that social norms could provide benefits to healthy eating interventions. Moreover, a systematic review by Engbers et al. (Engbers, van Poppel, Paw, & van Mechelen, 2005) assessed the effectiveness of worksite health promotion programs on health-related behaviors during work, which suggested that environmental modifications can significantly influence physical activity and eating behaviors.

The notion of mHealth (mobile health) is defined by The Global Observatory as "medical and public health practice supported by mobile devices, such as mobile phones, personal digital assistants, and other wireless devices" (Kay, Santos, & Takane, 2011). In recent decades, the role of mobile technologies in healthy eating behaviors is becoming increasingly prominent, and the use of diverse mHealth tools is also growing in personal health management (Šmahel et al., 2018). For instance, Eat&Tell (Achananuparp, Lim, Abhishek, & Yun, 2018) is a mobile application designed to facilitate the collection of eating-related data through automated tracking and self-reporting. Fitocracy Macros (Higgins, 2016) tracks macronutrients and helps users achieve fitness goals. MyFitnessPal (Evans, 2017) converts the barcode information on the food package into nutritional values to provide a clear view of intake in the form of calorific or nutrients and give related eating suggestions. Additionally, the rapid advance of digital technologies offers many possibilities to improve daily eating practices. Data collected from health tracking applications can support self-reflection on eating behaviors and improve the self-awareness of eating decisions (Parker & Grinter, 2014; R Wing & Hill, 2001). For example, Hartwell et al. (Hartwell et al., 2019) designed the FoodSmart app to inform users about food consumption and give intake suggestions according to individual preferences. Sysoeva and colleagues (Sysoeva et al., 2017a) composed a mobile channel to provide healthy food choices via text and voice communication. Although these applications mentioned above were useful for healthy eating in the short term, they should also address the full range of environmental and behavioral factors over the long term with scientific evidence (Rivera et al., 2016).

Recently, mHealth apps are being developed specifically aimed at preventing health risks in the working contexts (Gray, 2015; Nield, 2014), but it only shows the potential rather than the effectiveness of such apps (de Korte, Wiezer, Janssen, Vink, & Kraaij, 2018). When applying these mHealth technologies and digital tools to the working contexts, it appears to be challenging to generate desired health promotion outcomes, since working-age individuals normally abandon using these apps because it takes too much effort to keep using them in work routines (Lazar et al., 2015a; Zhu et al., 2008). On the other hand, eating activities can be heavily influenced by socio-cultural contexts, particularly in public settings. According to Hofstede (Hofstede, 2011), people with different cultural backgrounds may hold different values on six dimensions: individualism, masculinity, long-term orientation, power distance, uncertainty avoidance, and indulgence. Such varied cultural values could determine people's eating patterns to some extent. For instance, in highly individualistic countries (e.g., the Netherlands), people do not mind eating at different time slots (De Castro, Bellisle, Feunekes, Dalix, & De Graaf, 1997). Whereas people in collectivistic countries (e.g., China) tend to eat together in the social environment (Stajcic, 2013). In fact, health interventions and digital technologies are commonly designed without a deep understanding of the socio-cultural contexts, which can limit their effectiveness (World Health Organization, 2019). Particularly, it comes as a surprise that little research has been done to identify digital tools' design opportunities for promoting healthy eating routines dedicated to the daily working context and routine.

To promote healthy eating among working-age individuals, there is an urgent need to understand this specific context's challenges and opportunities to design and develop dedicated digital tools. In this chapter, (1) First, we take a user-centered and context-specific view (Holtzblatt, 2009; Holtzblatt, Wendell, & Wood, 2005) to qualitatively understand the context and also explore the user requirements for enlightening the future design opportunities of eating-related digital tools. We set out this research in the Netherlands, where the majority of full-time working-age individuals work for eight hours per day and five days per week, and have at the minimum one meal in the office during the day (Jastran, Bisogni, Sobal, Blake, & Devine, 2009). This situation makes the workplace an essential setting for the intervention design to promote healthy eating. (2) Secondly, based on the series of questionnaire and semi-structured interviews in the contextual inquiry, we derived a set of design requirements for relevant digital technologies, which led to the design of EAT@WORK. EAT@WORK is a mobile application that attempts to support individuals in developing healthy eating behaviors during daily working routines. The prototype of EAT@WORK was tested through a within-subject user study with 14 office workers, which aimed to examine the user acceptance of EAT@WORK features and gain more design insights into updating future mHealth applications in the working context.

3.2 Study 1: User Inquiry

3.2.1 Method

We set out a user-centered contextual inquiry involving an online questionnaire based on the format of sentence completion (Kujala, Walsh, Nurkka, & Crisan, 2014) and a semi-structured interview (Kallio, Pietilä, Johnson, & Kangasniemi, 2016). The Ethical Review Board approved this project at the Eindhoven University of Technology, the Institutional Review Board of Partners Healthcare: reference ERB2020ID8. Before each type of study, participants were reminded about the study's goals and that all information would be kept confidential and in a secure location. Participation in both the questionnaire and the interview studies was fully voluntary, and the participants did not receive any incentive.

Study Design

The Sentence-Completion Questionnaire

The questionnaire study's goal was to understand the context and gather some assumptions for the semi-structured interview. This study was advertised and spread via social media posts (e.g., on Facebook and Twitter), emails, and word of mouth to recruit respondents. People who (1) engaged in office-based knowledge work for more than 6 hours per day, (2) had been working in the Netherlands for more than six months, and (3) without a special diet were included. The study candidates who matched our inclusion criteria were presented with a consent description of the questionnaire and agreement to participate in the study to start the survey. Afterward, they would start filling in the sentence completion tasks individually for each category. In the end, questions related to demographics were asked, including age, gender, level of education, and occupation.

The questionnaire study was aided by sentence completion tasks (Kujala et al., 2014) to encourage working-age individuals to disclose their concealed experiences and opinions. As a semi-structured projective technique, the sentence completion task is designed with unfinished sentences. As such, the respondent has the freedom to interpret and complete the sentence based on their wish (Kujala et al., 2014). The sentence completion technique has been widely applied in HCI and design studies and proved effective in assessing user experiences, behavioral motives, and expectations towards new technology (Soley & Smith, 2008). In our questionnaire, all the sentence completion tasks were designed based on the first-person perspective (Kujala & Nurkka, 2012). E.g., "*In my workdays, I normally have lunch at* _______." By doing so, we aim to support the respondents to think along with our questions and engage in reflecting on their daily practices related to eating and using technologies in their working contexts. To consolidate our questionnaire, we circulated a draft to two external researchers to review items and suggest improvements for wording. In this study, the questionnaire was implemented using SurveyMonkey. The completed version of the questionnaire can be found in Appendix A-1. All the questionnaire responses were anonymized and exported from the SurveyMonkey platform as an Excel sheet that was only accessible by the research team for data analysis.

The Semi-Structured Interview

The interview study was set out to identify design opportunities for digital tools that can enhance individuals' eating routines at work and find out strategies to apply digital health to the eating routines in the working context in the Netherlands. We recruited participants by spreading information via word of mouth, taking a snowball sampling approach. Initially, we asked people we knew who had similar characteristics to our target subjects. We then asked them to pass the information to their social contacts. During recruiting, we screened study candidates based on inclusion criteria identical to those in the questionnaire study. Prior to the study, we explained the study's procedure and purpose to participants in detail and obtained consent upon their voluntary participation. They were also given the opportunity to withdraw at any point in the study.

All the interviews were semi-structured (Kallio et al., 2016) with a set of open-ended questions. The benefits of adopting semi-structured interviews are engaging participants in sharing their opinions based on the interview guidance to obtain in-depth and reliable insights into research questions (Gillham, 2005). This interview protocol was drafted, reviewed, and discussed by all research team members. All interview sessions were organized in two parts: First, we began by inquiring about participants' recent experiences with workplace eating routines. E.g., "*How do you like your eating routine during workdays?*" "*Have you and your organization done anything to improve your eating routine at work? And why?*" and "*What would you expect in the future to aid the eating aspect of your workdays?*" Second. we discussed opportunities to design digital tools for enhancing their eating routines and practices in the working context with two open-ended questions: "*What ideas come to your mind for using digital technologies to enhance your eating habits at work?*" and "*What food-related features do you expect in the future technology?*" During the interview, we left enough space for participants to elaborate on their opinions freely. Besides, we also asked them to explain some interesting statements that had emerged from the discussion. Each interview session took between 18 to 39 minutes, was audio-recorded, and later transcribed for qualitative analysis.

Qualitative Data Analysis

The questionnaire and interview data were analyzed respectively by thematic analysis following inductive coding (Thomas, 2006). Specifically, our data analysis proceeded as follows: To begin with, one researcher (the author) divided the responses to the questionnaire and interview transcripts into labeled statements through repeated reading. Next, the researcher measured the labeled statements using affinity diagrams (Kawakita, 1991) to identify recurring clusters and emergent themes. According to the member check approach (Birt, Scott, Cavers, Campbell, & Walter, 2016; Koelsch, 2013), all the identified themes and clusters were reviewed, discussed, and revised through several iterations with all members from the research team to validate the qualitative analysis.

3.2.2 Results

Description of Participants

The Sentence-Completion Questionnaire

The questionnaire study was conducted over a period of one month. A total of 86 responses were received, and 32 were excluded due to incomplete demographic information. Therefore, data from the 54 respondents (gender: 36 females and 18 males, age: M = 32.95, SD = 9.84, Min = 26, Max = 62) were eventually used for analysis. The characteristics of the respondents are summarized in Table 3.1.

Table 3.1 The demographics of the questionnaire respondents (N = 54).

Characteristics	Category	N	Percentage
Age	18 to 29	32	59.26%
	29 to 59	21	38.89%
	60+	1	1.85%
Gender	Male	18	33.33%
	Female	36	66.67%
Working years	0 to 5 years	35	64.81%
	5 to 20 years	11	20.37%
	20+ years	8	14.81%
Education	Secondary level	2	3.70%
	Bachelor	15	27.78%
	Master and above	37	68.52%

The Semi-Structured Interview

For the interview study, 17 knowledge workers were recruited to participate. Eventually, five participants dropped out due to unexpected changes in their agenda that conflicted with the interview holding time in the study course of two weeks. Therefore, we report results from interviews with the remaining 12 participants (gender: 10 females and 2 males, age: M = 39, SD = 11.52, Min = 26, Max = 54, working experiences: M = 16.21, SD = 13.00, Min = 0.5, Max = 35). The characteristics of the interview participants are summarized in Table 3.2. We labeled recruited participants as P1 to P12.

Table 3.2 The demographics of the interviewees (N = 12).

ID	Sex	Age	Education level	Working years	Working hours/day	Type of occupation
P1	F	26	MBO [1]	0.5	8	Secretary
P2	F	53	HBO [2]	35	8	Secretary
P3	F	44	HBO [2]	20	8	Secretary
P4	F	26	Bachelor	3	8	Secretary
P5	M	27	Master	2	8	Junior researcher
P6	F	30	PhD	8	8	researcher
P7	M	52	HBO [2]	30	8	Administrator
P8	F	54	HBO [2]	32	8	Office Worker
P9	F	25	Master	1	8	Administrator
P10	F	40	HBO [2]	22	8	Secretary
P11	F	46	HBO [2]	26	8	Administrator
P12	F	45	HBO [2]	15	7	Human resource

[1] MBO: vocational training; [2] HBO: bachelor's degree in applied science.

Consideration Influencing Current Eating Routines

In general, most participants (43 out of 54) chose to have their lunch around 12:00 in noon with occasional snacking as beneficial micro-breaks (Geurts, van Bakel, van Rossum, de Boer, & Ocké, 2017) in their working contexts. This situation is in line with the recommendations for lunch and snack breaks, according to Gronow and Jääskeläinen (Gronow & Jääskeläinen, 2001). For the majority of office-based jobs in the Netherlands, it is common to embed an unpaid time slot into the work schedule as a lunch break (Tucker & Folkard, 2012). It has also been suggested that having snacks regularly can replenish needed energy and nutrition in the work routines (Deuster, Kemmer, Tubbs, Zeno, & Minnick, 2012). Additionally, we received a wide variety of reasons behind the patterns of their workday eating routines, which can be classified into the following aspects, including productivity, health, energy support, and well-being (Table 3.3).

Well-being Many respondents (n = 45) valued eating-related activities in the working context as meaningful to physical, social, and mental well-being. For instance, they believed that social interactions during lunchtime could bring various benefits, such as "*relief from work*", "*exchange ideas on the project*", "*improve collaboration and social relationships*", and "*improve joyfulness*". Moreover, sharing food with colleagues was also beneficial to promote social dynamics.

Productivity Twenty-eight respondents expressed their concerns over maintaining productivity in eating routines with the following decisions: short-time lunch at the workstation (n = 28), eating alone (n = 13), and choosing light and convenient food (n = 23). Their reasons behind these eating patterns were, e.g., "*saving time for work*", "*keeping the mind clear in the afternoon*", and "*becoming fitter and healthier*".

Table 3.3 Considerations that lead to current eating routines among Dutch office workers.

Consideration	Defined Example
Wellbeing (n = 45)	*"My colleagues and I like sharing our snacks with each other. The most important thing 'from sharing the snack' is that it brings us a casual ambiance in the working routine and regular social-based breaks."* *"I have fixed time slots to eat some snacks in the office. These short breaks are relieving."* *"When I eat, I also prefer walking for a while to refresh my mind and body."*
Productivity (n = 28)	*"I don't like to spend much time for lunch because I have a tight schedule. And it's very convenient to take lunch at my desk."* *"Eating in my office doesn't influence my work that much, so it is my first choice."* *"I often buy fast/easy food in advance or in the supermarket nearby. Then I don't need to pay attention to what I need to eat and save my time to keep working."*
Health (n = 24)	*"I think it is healthy to leave my workspace and have a physical break at lunch."* *"Because I like to have lunch with co-workers, so we keep a similar schedule about when to eat."* *"We discuss food and share our cooks, which is enjoyable and lets us be more aware of our diet and health."* *"I try to eat healthier food, such as nuts, yogurt, and fruits (like apples/bananas)."*
Energy support (n = 11)	*"During working time, I eat chocolate and cookies a lot. I can eat more when my colleagues share some with me."* *"When I skip my lunch, I prefer to eat some chocolate or candy to gain energy to support my body in a fast way."*

Health Twenty-four participants indicated their needs for high-quality food and health-promoting activities during the lunch breaks, such as having lunch with balanced nutrition and eating outside of the workplace for a physical and mental break. Moreover, 19 respondents believed that eating fruits as snacks at work could be an effective way to improve their health conditions. Several participants (n = 6) also considered a small portion of nuts as a healthy eating practice during working hours.

Energy Support Eleven respondents indicated that food intake behaviors in the working context were essential as an energy supplement for their workdays, particularly some energy-boosting snacks (e.g., chocolate, cookies, candy, and muffins). A few (n = 3) further stressed the necessity of having energy drinks (e.g., coffee) to keep up their work performance.

Expected Features of mHealth Digital Tools

After the qualitative analysis of the interview study, 259 quotes were selected. All selected quotes can be categorized under four main themes (as shown in Table 3.4) as technological features of digital tools for promoting healthy eating in the working context, namely support accessing relevant knowledge, enable planning and goal setting, combine with health programs, and facilitate social supports.

Support Accessing Relevant Knowledge During the interviews, most participants expressed their interest in obtaining knowledge for improving healthy eating behaviors. Spontaneously, some of them tried to find relevant information from the third party to enrich their 'knowledge base'. For instance, P4 used to read informative articles of some nutritionists she followed on Facebook; P9 subscribed to a magazine called Health to gain information about diet advice; P12 watched scientific videos about healthy eating via an online platform called Game Changer; P2 was a P.E. teacher in a university, she could use university's online library to learn more about the relationship between healthy eating and physical vitality. They believed that the increase in eating-related knowledge served as a motivational factor that contributed to fostering healthy eating behavior and attitude change. Therefore, they expected tools, such as a digital platform, would help them learn the desired knowledge systematically. In this study, our participants stated several aspects of knowledge that could be meaningful to improve the workday eating routine, including the influences of (un)healthy eating and the recommendations for healthy ingredients of office food.

Enable Planning and Goal Setting We found that some participants created eating goals as a strategy to, e.g., prevent potential chronic disorders, improve well-being, and lose weight. In general, these goals were described in two kinds: 1) eat more regularly to support a healthy daily routine; and 2) eat with more balanced nutrition for a healthier lifestyle. To aid these kinds of goal settings, some participants expected digital tools similar to activity tracking applications (e.g., Fitbit), which could easily allow the user to set healthy eating goals. They also preferred this system to provide suggestions for supporting the user in reaching health-promoting goals. For instance, from this study, we learned that some interviewees (P1, P3, P5, P12) wanted an app to generate a grocery shopping list and recipes according to their goals and personal eating habits.

Combine with Health Programs We learned that almost all interviewees easily connected their healthy eating practices with other health promotion means, such as physical activity. Examples include running (P3, P8, P10, P11), yoga (P2, P4, P6, P8), swimming (P5, P7), boxing (P1), and cycling (P7). They pointed out that the underlying reason was that a good eating routine alone might not be enough to improve their health conditions. It would be beneficial to maintain healthy eating while increasing physical exercise in the daily routine. Additionally, some participants literally combined eating with some relaxation breaks to add micro-health benefits in the working context. Nevertheless, our interviewees found it challenging to keep up their engagement in multiple health-promoting activities, especially during a hectic workday. To address this problem, one suggestion received during our interviews was to facilitate a structured health program consisting of multiple activity plans (e.g., healthy eating, relaxation, and physical activity) to guide the working-age individuals to improve their health step by step. Furthermore, some participants recognized that digital technologies, such as virtual coaches, reminders, or rewarding mechanisms, could be applied to encourage individuals to adhere to these kinds of health programs.

Facilitate Social Support According to the interview results, social interactions with colleagues can play a crucial role in supporting healthy eating routines among Dutch office workers. Most interviewees (P1–2, P4–5, P7, P9–12) suggested the dual benefits of committing to eating-related social activities. On the one hand, they indicated that eating together with colleagues could strengthen social bonding and enhance mental well-being during work. On the other hand, having lunch together or sharing food with each other was also deemed an effective way to increase self-awareness of eating healthy. For example, P5 recalled that he sometimes compared his eating behaviors with coworkers' during lunch, which was helpful for making some improvements afterward, such as slowing down the chewing speed. Moreover, some individuals (P2, P4, P8, P9) described their experiences sharing snacks (e.g., cakes and fruits) frequently with colleagues, which made them more conscious about choosing healthy snacks during working hours. Although the workday eating routines were loosely connected to those social activities, our participants expected that digital tools could further leverage social mechanisms to augment such peer support. For example, P4 suggested developing an online health-promoting community within her department so that they could share their experiences and achievements as well as help each other. P12 described an intelligent system that could help colleagues with similar eating-related health goals create a mutual support team to enhance goal commitment.

Table 3.4 Aspired digital tools to improve eating routines.

Feature	Defined Example
Support accessing relevant knowledge	*"I learn nutrient knowledge online. As my knowledge grow, I improve my eating practices a lot."* (P4) *"Some online scientific videos help me know why I must eat healthy. I also want to know more information about healthy food and eating."* (P12) *"Years ago, I wanted to lose some weight, so I got some useful knowledge about healthy eating. Now, I try again to eat healthy, but I cannot find the trustworthy information anymore."* (P6)
Enable planning and goal setting	*"Setting health goals is useful to me. I could be motivated for a long period."* (P7) *"I have a weekly eating schedule on my computer screen. I modify my eating schedule at the end of each week, like playing a puzzle game, and check what I eat for each day during the week."* (P12) *"I prefer to take notes on my phone about what I want to cook for the next week. It can help me prepare my grocery shopping lists."* (P5) *"I hope some technologies can help me decide what foods to eat. For example, it can recommend me the type of lunch and snacks and calculate calories accordingly."* (P2)

Combine with health programs	*"Swimming helps me to be more aware of keeping my eating routine healthy and regular."* (P5) *"I do physical exercises once or twice per week. This helps me pay attention to eating healthier and more balanced food."* (P1) *"I try not to waste any opportunity to have a mini break during my working hours and eat something during such a mini break is relaxing."* (P12) *"I know doing more physical activity is good, but I don't know how to arrange it within my busy agenda other than reminding myself to walk for a while after my lunch."* (P9)
Facilitate social support	*"I like eating lunch with others. When I eat alone, I normally eat very fast, which I know is unhealthy. But chatting with others helps me to eat slowly."* (P5) *"I feel good when my colleagues see my lunch delicious, and we often share cooking experiences during lunch."* (P4) *"I like eating lunch together so that we can chat and share interesting information." and "My colleague and I like sharing food with each other. This gives us a short time for chat and have a rest."* (P2) *"My colleague sitting next to me likes to share snacks with me, and this made our eating time and routine identical. The good result is I became more aware of eating fruits."* (P4) *"When any colleague celebrates a birthday, we are so happy to have some cakes and snacks together."* (P3) *"I am very encouraged to see some influencers on Instagram sharing their healthy eating experiences frequently."* (P4)

Strategies to Apply Digital Tools into the Working Context

Our interview participants indicated that both technology and eating routines in the working context could be largely affected by various contextual determinants, such as the workflow and the working environment. All the participants believed that the technological features of the digital tools should be adapted according to the everyday context to improve eating routines at work. Their feedback was selected as 116 quotes and analyzed into two major aspects (as shown in Table 3.5): Integrating health-promoting digital applications into the working context and Providing system feedback according to individual differences.

Integrating Health-Promoting Digital Applications into the Working Context From the interview, many participants expressed their concerns about overusing digital tools to improve eating patterns because the use of nonworking-related technologies may increase their task load and distract their daily work. Some participants suggested that health-promoting technologies should be designed and implemented in combination with both the digital and physical infrastructure in the workplace. On the one hand, the majority of our participants indicated that some health-related features provided by mobile applications could be expanded further into different workplace software platforms. One suggestion received was embedding breaks with suggested foods into individuals' Outlook calendars to prompt and encourage healthy eating activities. On the other hand, participants expected improving eating routines at work as a simple behavior change without requiring too much effort. Therefore, they looked forward to more pervasive systems in the workplace that could be integrated into the office facilities, e.g., food trays in the company canteen, and snack machine at the coffee corner. As such, they hoped the system could collect, analyze, and give feedback on their individual eating-related practices unobtrusively without violating privacy concerns.

Providing System Feedback According to Individual Differences From this interview study, we learned that one general reason behind the low acceptance of digital tools for healthy eating was the lack of valuable suggestions and

Table 3.5 Recommended strategies to apply digital tools into workday eating routines.

Strategy	Defined Example
Integrating health-promoting digital applications into the working context	*"I can track my eating behaviors. But I am not motivated to do so when I am working, because I can easily forget to put information into the technology."* (P1) *"People may not commonly be motivated to change their eating habits, as we don't see the benefits for office people."* (P4) *"I like following schedules without extra effort. When I am busy with work, I don't have time to think about my eating routine and health. If technology can combine eating activities with my agenda, I think I will be more likely to follow it."* (P7) *"I don't have time to remember when I need to log my eating information. I hope the eating behaviors and food content could be tracked in some easy ways."* (P11)
Providing system feedback according to individual differences	*"If future technology can learn my routine and situation in a positive manner, maybe I will try to follow its advice."* (P2) *"When I eat some unhealthy food, I hope the technology can give me some very constructive tips to combat my unhealthy behaviors."* (P1) *"I hope the food-tracking app could learn my preference over time and could be changed based on my different needs in different periods."* (P4)

guidance based on divergent individual characteristics. To increase the adoption of digital technology for office eating routines, first, many participants wanted a more personalized service system. For instance, they expected the digital system to behave like a personal health specialist that could learn an individual's daily routine over time and provide customized suggestions according to his or her health- and work-related status. Secondly, several participants said they did not want to be bonded up with a digital tool for healthy eating entirely during the workday. Therefore, they suggested that the system should allow them to easily subscribe/unsubscribe to different functions due to their subjective opinions or working conditions.

3.3 Study 2: User Study

3.3.1 Design of EAT@WORK

According to the user-centered inquiry study mentioned above, we summarize the main findings from the interviews, which led to the design of the EAT@WORK app. The EAT@WORK app was developed as an interactive prototype using the Abode XD software for the Dutch working context (i.e., office and home office). The prototype was compatible with both Android and iOS systems, with the following four key features.

Supporting Easy Access to Relevant Knowledge

Our interview study suggested that nutrition knowledge could help working-age individuals adhere to healthy food options and achieve eating goals. Nevertheless, the credibility and quality of health-related knowledge from the internet were critically concerned. The mixed quality of third-party resources has made it challenging for users to find the correct information for the target health behaviors. One solution could be a platform that connects to reliable data resources (e.g., health authorities, food suppliers, health services, and health experts) for valid knowledge of healthy eating.

The corresponding feature of EAT@WORK is an integrated tool that ensures easy access to nutrition info from trustworthy knowledge providers, who are listed under the "*All*" view (Figure 3.1 (a)). In addition, the user can search for specific knowledge (Figure 3.1 (c)) and make their own collection by subscribing to different knowledge providers (Figure 3.1 (b)). Then, in the "*Subscribe*" view, it will provide the updates in real-time from those knowledge providers subscribed by the user (Figure 3.1 (d)).

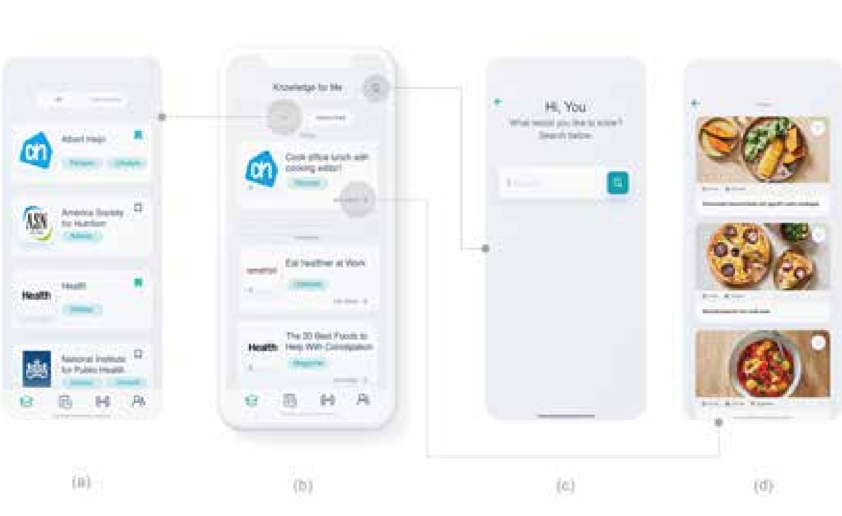

Figure 3.1 The collection of relevant knowledge for improving the worker's eating routine. (a) full list of recommended knowledge providers; (b) list of subscribed knowledge providers; (c) search function; (d) specific info of one subscribed provider.

Assisting in Setting up and Achieving Eating Goals

Figure 3.2 The user interfaces for assisting workers in achieving eating-related health goals. (a) setting personal eating goals and keywords; (b) eating plan and intake tracking for working hours and non-working hours; (c) weekly review of goal achievement and plan for the next week; (d) direct to supermarket apps for efficient grocery shopping.

According to our interviewees' suggestions, specific and measurable eating goals could help working-age individuals formulate healthy eating behaviors. However, the eating conditions during working hours were always influenced by their personal working routines. One solution could be a platform connecting to users' working schedules for planning proper eating time. Another challenge revealed by the interview is that a long-term eating goal with limited feedback would demotivate users to adopt digital tools for healthy eating promotion. Thus, assisting users in setting short-term, achievable mini-goals and providing regular feedback could be an effective solution to establishing healthier eating routines during working hours.

The feature in the "*Today*" view facilitates the self-tracking of eating activities easily during both working hours and non-working hours through a time-dependent checklist (Figure 3.2 (b)). The "*History*" view presents the historical data of the goal commitment as weekly summaries (Figure 3.2 (c)). Users can also find recipe suggestions and shopping recommendations (e.g., recipes, grocery shopping lists, and eating plans) based on their historical data (Figure 3.2 (d)).

Integrated Health Program

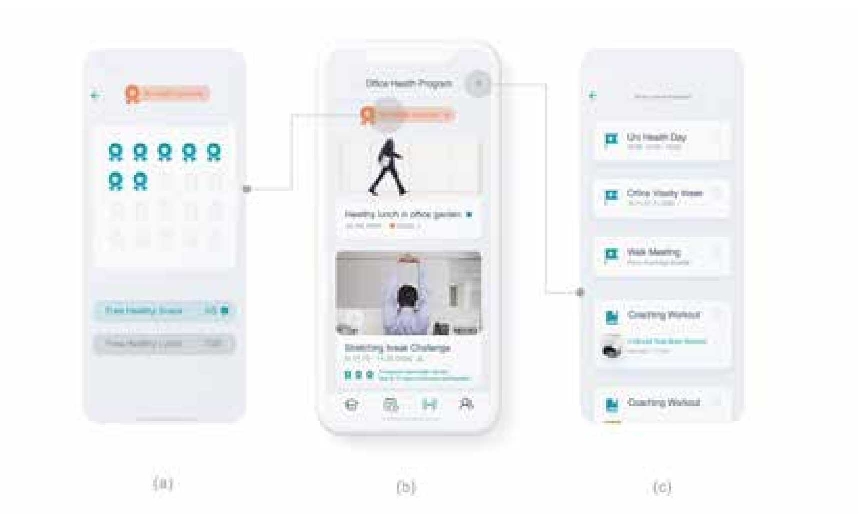

Figure 3.3 The service facilitates the worker to participate in integrated health programs in the organization. (a) summary of received rewards; (b) followed health program and the completion status; (c) a list of recommended health programs.

As suggested by our interviews, a structured health program containing different interventions for promoting overall health is essential to reduce the negative

influence of the daily work routine. Additionally, our interviewees believed that digital technologies (such as mHealth apps and health websites) could support their adoption of health programs in the working context over time. One suggested solution was a particular system with suggestions, challenges, and rewards for users to balance their nutrition and physical activities during working hours.

As shown in Figure 3.3 (b), under the "*Office Health Program*" tab of EAT@WORK, the user can follow a list of health-promoting activities organized by the company (e.g., working exercises) or suggested by the system (e.g., lunch stroll due to good weather). By completing these activities as health challenges, the user enables to receive virtual rewards, such as digital coupons used in the canteen and supermarkets to purchase healthy foods with a discount (Figure 3.3 (a)).

Facilitating Peer Support for Healthy Eating Routines

Our interview results showed that interviewees preferred eating with colleagues who shared similar eating routines. They also tended to consult others' eating patterns and food choices as guidance. Therefore, a social platform that leverages peer support between colleagues could potentially encourage healthy workday eating patterns.

As shown in Figure 3.4 (a) and (b), the system helps users with similar health goals or eating patterns to team up with each other as a health-promoting dyad at work in the "*Buddy*" view. Once two users become buddies, they can check each other's goal completion in real-time and nudge each other via the app. The "*Community*" view facilitates a group of colleagues (e.g., coworkers from the same department, people in the same working group) to share health-related information (e.g., external knowledge, personal experiences, and questions) to encourage healthy eating via mutual interventions (Figure 3.4 (c) and (d)).

Figure 3.4 The social platform leverages peer support among colleagues to encourage healthy eating. (a) health-promoting dyad with a similar eating goal; (b) a list of recommended users with similar eating goals; (c) a social platform that leverage peer support among colleagues and co-workers; (d) post personal health-related info to others.

3.3.2 Materials and Methods

This user study aimed to investigate 1) the user acceptance of EAT@WORK; and 2) design opportunities and challenges for the future application of EAT@WORK. For these purposes, Figure 3.5 shows that a within-subject experiment was designed to compare the user acceptance of our interactive prototype with an existing mHealth system for healthy eating, followed by a co-creation session to qualitatively evaluate and discuss how the UX features of EAT@WORK could be improved and applied in different working contexts (i.e., telework vs. office work). The benchmark mHealth technology used in this study is Traqq (Brouwer-Brolsma et al., 2020), a dietary assessment app that can be used as a recall and

food record in the Dutch societal context. The study has received Ethical Review approval at the Eindhoven University of Technology, with the reference number: ERB2020ID8.

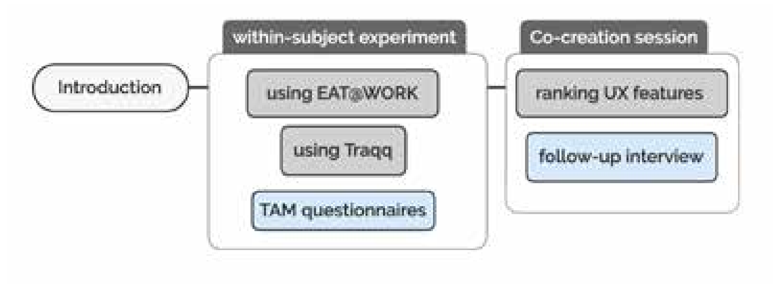

Figure 3.5 A visualization of overall study procedure.

Participants

We recruited participants by spreading information via emails and public posts on social media such as Facebook and Twitter. We also invited participants from our previous semi-structured interview (as presented in Study 1) who contributed insights into the concept development of EAT@WORK. Due to COVID-19 regulations, all the participants had to work from home during the period of our study (November – December, 2020). Prior to the study, none of the participants had the using experiences with EAT@WORK and Traqq. They were fully informed of the study's purpose and procedure, signed a consent form in advance, and were allowed to withdraw at any point of the study.

Study Design

In accordance with the COVID-19 regulation, we conducted the study via remote meeting software (i.e., Microsoft Teams) and an online survey system (i.e., Microsoft Form). The study with each participant took around 65-80 minutes for the entire process, which consisted of a within-subject experiment and a co-creation session. Next, we describe the two sessions in detail.

Within-Subject Experiment Each experiment was divided into two conditions using EAT@WORK and Traqq, respectively, with the following procedure. For each condition, we first introduced one of the two apps by sharing our screen. We then sent a link containing the download address of the app and asked each participant to experience different app features for 15 minutes. Afterward, we asked the participant to fill in a short version of the Technology Acceptance Model (TAM) questionnaire developed by Davis (Davis, 1989) based on their user experiences with the app. The completed version of the TAM questionnaire can be found in Appendix A-2. Upon the completion of the TAM questionnaire, we invited the participant to enter the next experiment with another condition following the same process as described above. The exposures to the EAT@WORK and the Traqq conditions were fully counterbalanced in our study. The comparison between these two apps was to verify whether EAT@WORK would receive reasonably high user acceptance during working hours. Thus, our first hypothesis is:

> **H01:** The EAT@WORK app will be be more useful and easier to use by office workers than Traqq.

Additionally, given that our study involved both experienced subjects (who participated in the earlier Study 1) and non-experienced subjects, we were also interested in knowing if such a difference would influence their acceptance of EAT@WORK. Therefore, the second hypothesis is:

> **H02:** The responses on the TAM questionnaire between the experienced and non-experienced participants will not be significantly different.

Co-Creation Session To aid the interpretation of our quantitative comparison, we asked every participant at the start of this session: "*Which app do you prefer to use during your working hours?*" and "*Please describe the reason for your choice.*", individually. As shown in Figure 3.6, we also prepared a Miro dashboard to facilitate online co-creation session. On the right side of the dashboard, we present the four UX features of EAT@WORK (knowledge for me, goal assistant, health program, and social support). On the left side, we asked the participant to rank four features regarding their applicability to the office working context and the work-from-home context, respectively. The participant was then asked to explain their choices with three open-ended questions, which were developed according to the Mobile App Rating Scale (Stoyanov et al., 2015). The questions were "*Why do you rank features during your working hours in the office and at home in this way?*" "*Please describe why you like or dislike each feature and share your ideas for further improvement.*" and "*Do you have any ideas, comments, or suggestions concerning the use of digital applications during your working hours?*" Every participant was given enough space to express their opinions.

Figure 3.6 The screenshot of our Miro co-creation dashboard.

Data Collection

For the quantitative data, we collected participants' responses to the TAM questionnaire and created screenshots for the rankings of different UX features during the co-creation session. We used two subscales of TAM: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). In the questionnaire, each subscale contains six items, and each item has been designed as a seven-point Likert scale (from 1 - extremely unlikely to 7 - extremely likely). For the qualitative data, we audio-recorded each interview and transcribed interview content later for analysis.

Data Analysis

Quantitative Data The responses to the TAM questionnaire were analyzed using the SPSS software. Firstly, we processed the quantitative data with descriptive statistics, in which we checked the distribution of the PU and PEOU data through Shapiro–Wilk tests, which showed no significant difference with the normality ($p > 0.05$). Thus, the two-way mixed ANOVA was conducted with the user experience sessions with different prototypes (EAT@WORK vs. Traqq) as dependent variables and the type of participants (experienced participants vs. non-experienced participants) as independent factors. Where ANOVA was significant, pairwise comparisons were processed. The main objective of quantitative analyses was to examine the acceptance and usefulness of EAT@WORK.

Qualitative Data The interview data were analyzed by thematic analysis following deductive coding (Braun & Clarke, 2006) using the MAXQDA software. Specifically, our data analysis proceeded as follows: To begin with, one researcher (the author) transcribed responses and labeled statements using affinity diagrams (Kawakita, 1991) to identify clusters and themes. Next, according to the member check approach (Birt et al., 2016; Koelsch, 2013), all the identified themes and clusters were reviewed, discussed, and revised through several iterations with all the research team members to validate the qualitative analysis. One main objective of qualitative data results was to indicate the importance and relevance of our quantitative data. Another purpose was to gain design insights into future developments of healthy eating technologies for working-age individuals.

3.3.3 Results

Description of Participants

In total, 14 participants from various working-based jobs in the Netherlands were recruited. Seven participants who took part in our early semi-structured interview study were named as experienced subjects (ES), while the rest of the newly recruited participants were named as non-experienced subjects (NS). These 14 participants (gender: 10 females and 4 males, age = 34.36 ± 10.20, working experiences = 12.26 ± 13.18) were labeled as P1 to P14. Their characteristics are summarized in Table 3.6.

The User Acceptance of EAT@WORK

Quantitative Findings

As shown in Figure 3.7 (a), the perceived usefulness (PU) of the EAT@WORK prototype was rated with a mean of 5.36 (SE = 0.39) by experienced subjects (ES) and 5.43 (SE = 0.16) by non-experienced subjects (NS). In contrast, the PU of the Traqq app was scored at 4.12 (SE = 0.49) by ES and 3.48 (SE = 0.33) by NS. The 2x2 ANOVA revealed that the PU between EAT@WORK and the Traqq app was

Table 3.6 The demographics of the 14 participants
(MBO: secondary vocational education, HBO: higher vocational education).

Group	ID	Sex	Age	Education level	Work years	Work hours/ day	Type of occupation
Experienced Subjects (ES)	P1	F	45	HBO	21	8	Secretary
	P2	F	27	Bachelor	4	8	Secretary
	P3	F	54	HBO	36	8	Secretary
	P4	M	28	Master	3	8	Junior researcher
	P5	F	31	PhD	9	8	Researcher
	P8	M	26	Master	2	8	Junior researcher
	P10	M	30	Master	5	8	Program director
Non-Experienced Subjects (NS)	P6	F	27	MBO	1.5	8	Secretary
	P7	F	28	Master	3.5	8	Junior researcher
	P9	F	55	HBO	33	8	Office manager
	P11	M	28	Master	2	8	Office manager
	P12	F	26	Master	2.5	8	Researcher
	P13	F	38	Bachelor	15	8	Entrepreneur
	P14	F	38	Master	15	8	Program director

significantly different (F = 42.85, $p < 0.01$), while the participation experiences did not affect the PU scores (F = 2.15, $p = 0.168$). The pairwise comparison showed that

the usefulness of EAT@WORK (M = 5.39, SE = 0.20) was perceived as significantly higher ($p < 0.01$) than Trapp (M = 3.80, SE = 0.30).

As shown in Figure 3.7 (b), the perceived ease of use (PEOU) of the EAT@WORK prototype was scored with a mean value of 5.71 (SE = 0.36) by ES and 6.10 (SE = 0.17) by NS. Traqq was rated at 4.86 (SE = 0.36) by ES and 5.14 (SE = 0.33) by NS in terms of PEOU. The 2x2 ANOVA revealed that the PEOU between EAT@WORK and Traqq has a significant difference (F = 22.07, $p < 0.01$), while there was no difference between the feedback from ES and NS (F = 0.061, $p = 0.809$). According to the pairwise comparison, EAT@WORK (M = 5.90, SE = 0.20) was perceived as significantly easier to use ($p < 0.01$) than Traqq (M = 5.00, SE = 0.24).

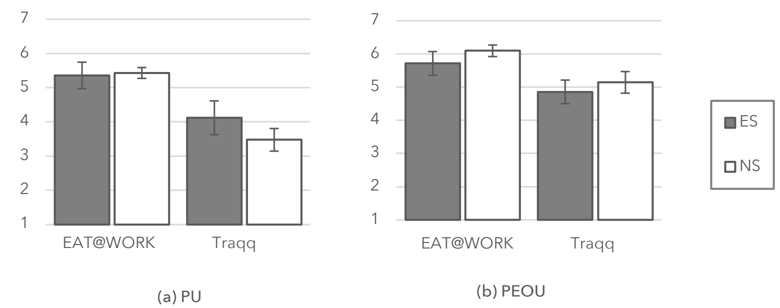

Figure 3.7 Mean and SE of TAM.

Qualitative Findings

According to interview feedback, all the participants showed a positive attitude toward using digital technology for health promotion during their working hours.

Compared to Traqq, all of them expressed their preference for using EAT@WORK to promote their workday eating routines in the future. The reasons for their choice can be summarized in the following aspects. First, they stated that they could see the potential benefits of this application because it included not only food tracking but also social and physical activities that are highly related to eating. For instance, some participants mentioned that "*It can also manage my physical activities, so I don't need to use another app.* (P1)" "*Having an eating buddy would really help me to eat on time and share eating-related information with each other.* (P8)" and "*I like reward setting in the prototype, which can motivate me to eat healthier foods.*" Second, the responses indicated that a well-designed interface helped users adopt the system in the short term. As P12 explained, *"I like the interface on this application...... a clear layout helps me easily use the app during working hours."*

The Applicability of EAT@WORK UX Features in Different Contexts

Quantitative Findings

The Rankings As shown in Table 3.7, the 'knowledge for me' feature received similar scores in the two working contexts, with an average rank of 2.93 for office-based work (ObW) and 2.85 for work-from-home (WfH). Regarding the UX feature of 'goal assistant', it was considered mostly desirable for both contexts, as it received the first rank eight times for ObW and 12 times for WfH. The 'health program' feature received mixed feedback between those two contexts. On the one hand, for ObW, nine out of 14 participants ranked this feature as the first or second, ranking its average at 2.07. On the other hand, only four participants ranked this feature as the first half in the context of WfH, resulting in its average rank of 2.86. Interestingly, we found that the UX feature of 'social' in EAT@WORK was ranked the least desirable, as 50% of our participants ranked it the fourth feature in both working contexts.

Table 3.7 The ranking of four features in different types of working context (office-based work vs. home-based work in our case).

UX features	Office-based work					Work-from-home				
	1st	2nd	3rd	4th	Avg.	1st	2nd	3rd	4th	Avg.
'Knowledge for me'	1	5	2	6	2.93	0	6	4	4	2.85
'Goal assistant'	8	4	2	0	1.57	12	1	1	0	1.21
'Health program'	5	4	4	1	2.07	1	3	7	3	2.86
'Social'	0	1	6	7	3.43	1	4	2	7	3.07

Qualitative Feedback From the follow-up interview, we learned several factors that led to the quantitative results of these UX features. First, almost all participants mentioned that a well-supported goal assistant during working hours could be beneficial to their personal health. For example, some participants stated: "*I prefer to have a scheduled eating plan no matter in the office or at home, so that I can balance my working routines with it in an efficient way.* (P7)" "*If the app could help me to plan my intake and achieve my eating goals step by step, it would save my time and let me pay more attention to my working tasks.* (P11)" In addition, some participants presented that the 'health program' could be more useful to ObW than WfH. As P2 described: "*When I work in the office, I have a more overwhelming work schedule than work from home. So, I need the app to arrange healthy activities for me.*" Although participants thought 'social' is a contextual determinant influencing their eating patterns, it was not as essential and necessary as the first two features during working hours. P14 mentioned that *"Due to COVID-19, I have less contact with my colleagues and friends. EAT@WORK provides a remote way to have a* *connection with them, which is good. However, I can eat with my family and share eating-related information. I don't think I need to use an app to support my eating and social activities unless I live alone.*" P3 said, "*I like this function, but I prefer using other functions than this one because face-to-face eating with colleagues in the office and with family members at home is quiet enough for me.*" Lastly, 'knowledge for me' was considered as an on-demand feature that would not be frequently used in the working contexts yet could be helpful on some particular occasions. For instance, some participants (P7, P8, P13, P14) stated that this feature might support them in preparing healthy work lunches, especially during the work-from-home period.

Extra Findings

From the interviews, we obtained a few qualitative suggestions for the future developments of EAT@WORK, which can be summarized into two aspects. First, some participants suggested that the prototype could be embedded into the desktop software or workstations. E.g., "*I don't always use my mobile phone when I work*. (P3)" "*It would be better if the prototype could be a real product around me and help me track my eating*. (P6)" and "*If I can get notifications and feedback from my laptop, that will be easier for me to use the system in a long term* (P11)". Second, participants expected the system could leverage machine learning to customize the user experiences and provide specific feedback. For example, P13 stated: "*It is better if the digital tool can learn when and how the office workers use the system and adapt its service flow according to the routine and habits of the user.*" And P1 mentioned that "*I really want to get some specific feedback based on my own situation, then I can decide what I should do and change accordingly to improve my eating.*"

3.4 Discussion and Limitation

Healthy eating can contribute to the overall health and vitality of working-age individuals (Canada, 2011). The rapid advance of mHealth technologies can play a crucial role in improving workday eating routines. In the working context, working-age individuals can be very busy with their tasks at hand throughout the day and should keep their performance following the implicit and explicit working rules (Reinhardt, Schmidt, Sloep, & Drachsler, 2011). Obviously, this situation can potentially create barriers to utilizing digital health technologies and adhering to health interventions during daily work.

3.4.1 User Inquiry

This study was conducted as the user-centered contextual inquiry, based on the sentence-completion questionnaire and semi-structured interviews, to identify design opportunities of digital tools to promote healthy eating routines in the Dutch working context. The questionnaire results indicated that the formation of workday eating routines could be mainly attributed to working-age individuals' considerations in well-being, productivity, health, and energy support. Moreover, the promotion of healthy eating at work could be facilitated by several strategies, such as easy access to relevant knowledge, eating goal and planning support, integrated workplace health programs, and social supports between coworkers. These findings emphasize the opportunities to embody contextual elements to encourage healthy eating routines, which align with a number of previous studies. For instance, a literature review by Nestle and colleagues (Nestle et al., 2009) indicated that gaining nutrition knowledge could motivate users to choose a healthier diet based on various food products. Hargreaves et al. (Hargreaves, Schlundt, & Buchowski, 2002) conducted a focus-group study and found that well-planned eating can improve the quality of individuals' diets and the healthfulness of dietary habits. A review study about social influence on eating by Higgs and Thomas (Higgs & Thomas, 2016) revealed that appropriate healthy eating actions are impacted by the comparison with other eating partners' behaviors. Based on our findings, we gained some valuable insights into technology features and digital health application strategies to help our target users gain healthy workday eating routines.

Besides, we also further derive an information system design as the underlying data infrastructure for healthy eating promotion (Figure 3.8). The aim of proposing this system is to facilitate the usage of such eating-related digital tools in the working context and support customized feedback. Next, we describe the major design of the system structure based on the findings from our user inquiry:

According to the interview findings, the data collection on eating-related behaviors in the working context could be combined with workplace facilities to avoid overburdening users and improve the adoption of digital health technologies. This insight clearly connects to the concept of automatic dietary monitoring (ADM) (Amft, 2008). Based on unobtrusive sensors, ADM aims to replace the self-report of eating behaviors with a sensor-based tracking approach embedded in the environment (Prioleau et al., 2017). For the context of this study, as shown in Figure 3.8 (a), we envision that data related to workday eating routines could be collected unobtrusively through ubiquitous sensors and software APIs embedded in the working context. In this way, the system is capable of building personal health databases. However, we also learned that study participants were generally concerned about their privacy and data security when using digital tools for personal health in public. To address this challenge, one feasible approach would be to encrypt the data (Li, Yu, Zheng, Ren, & Lou, 2013). Specifically, the personal health data should only be available to the user(s) with the corresponding decryption key. According to this consideration, Figure 3.8 (b) shows that the personal health

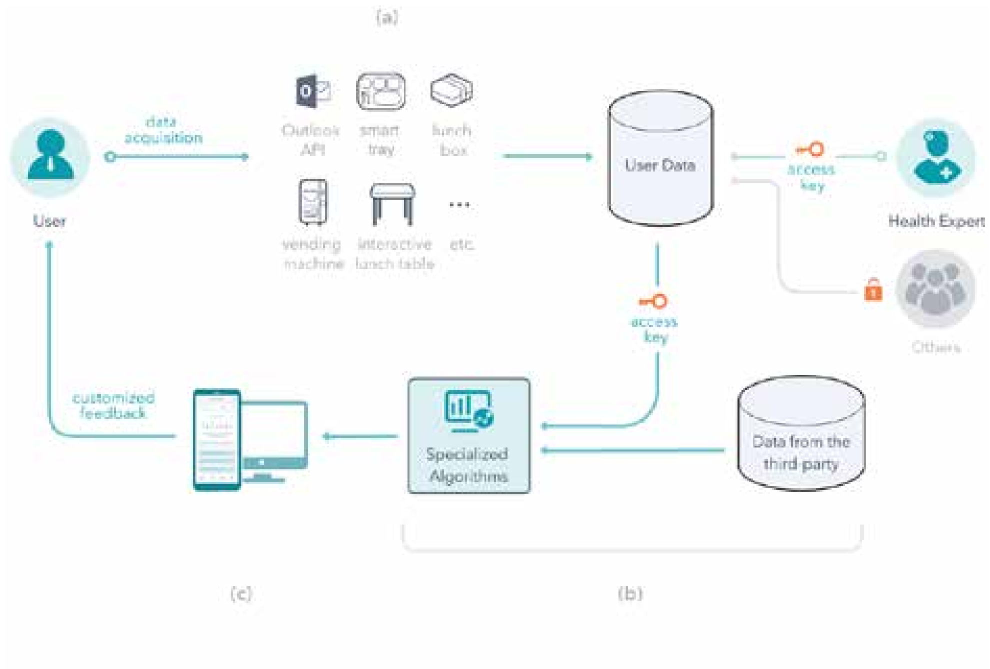

Figure 3.8 The proposed system infrastructure of the digital tool for supporting healthy eating at work: (a) the proposed data collection methods; (b) the data management and analytics; (c) the digital application for providing customized feedback.

databases should be encrypted and only accessible by the user and particular health professionals (e.g., general practitioners and company doctors), only with the unique identification keys. Moreover, as suggested by our research findings, some knowledge from external resources can be useful for promoting healthy eating. Therefore, the system is designed to connect relevant databases from a wide range of third parties, such as the health media and medical and healthcare organizations.

Another key finding of our inquiry was that questionnaire participants and interviewees wanted to receive personalized suggestions from their digital tools. This requires advanced algorithms (e.g., (Ambeba et al., 2015; Maes et al., 2011)) to achieve personalized feedback mechanisms and health interventions. For our research topic, we propose that both the user data and the third-party data will be gathered, processed, and analyzed through specialized algorithms to provide customized information to the user. This could be achieved through, for instance, adapting machine learning techniques for data fusion. As a result of the specialized algorithms, the system will be able to create personalized suggestions and different interventions based on individual health and work status, which will be presented through digital applications (Figure 3.8 (c)) to the user for assisting workplace health promotion.

3.4.2 EAT@WORK User Study

The user study focused on developing a mHealth application to promote healthy eating routines among working-age individuals and examining its applicability to the working context. According to the user inquiry study, we designed a mHealth application, called EAT@WORK, containing UX features of 'knowledge for me', 'goal assistant', 'health program', and 'social support'. To examine the usability and applicability of EAT@WORK, a formative user study was set out using a within-subject experiment and an online co-creation session. Both of our research hypotheses have been achieved. Our results revealed that EAT@WORK is more useful and easier to use by working-age individuals than Traqq, and there has no using difference between experienced subjects and non-experienced subjects.

Regarding the within-subject experiment results, the two-way mixed ANOVA analysis between EAT@WORK and Traqq app revealed that EAT@WORK was an easy-to-use and useful digital tool in facilitating healthy eating for working-age individuals. Participants showed a positive attitude toward using EAT@WORK because of its integrations among various eating-related elements (such as eating-related knowledge, health program, and social support) and its user-friendly and well-designed interfaces. Our results are consistent with earlier studies that embodying contextual elements (such as gaining nutrition knowledge (Nestle et al., 2009), well-planned eating (Hargreaves et al., 2002), and social influence on eating (Higgs & Thomas, 2016)) can improve the quality of individuals' diet and encourage healthy eating routines. Besides, easy learning interfaces and natural interaction between digital tools and individuals positively influence the acceptance of digital tools (Lu, Chen, & Chen, 2012; Zheng, Gao, & Li, 2009).

The results from co-creation session interviews indicated the applicability of EAT@WORK's four UX features ('knowledge for me', 'goal assistant', 'health program', and 'social'). Firstly, the 'goal assistant' feature could be helpful in planning eating routines and achieving eating goals in both office working and teleworking contexts. Secondly, 'health program' is more helpful to apply when people are working in the office than working from home. Thirdly, 'social support' was a useful feature but not the main factor affecting eating routines and behaviors during working hours. Fourthly, 'knowledge for me' was considered as an on-demand feature that could be helpful on some particular occasions.

Besides, the user study also revealed several future design developments of EAT@WORK. On the one hand, our findings suggested that mHealth tools embedded into the desktop software or workplace necessities could be more appropriate for promoting healthy eating among working-age individuals. This finding is in line with the research by Patrick and colleagues (Patrick et al., 2016), who found that using existing infrastructures could reduce additional investments from users, thus increasing technology adoption. On the other hand, customized user experiences and feedback were expected by most participants. This is in line with several previous pieces of research that tailored content and customized user feedback could help individuals to stick to promote their health (Coulter et al., 2015; Ordovas, Ferguson, Tai, & Mathers, 2018).

3.4.3 Limitations

As an exploratory study, we took the user-centered perspective and applied the qualitative user research approach. Our main goal is to explore design opportunities for digital tools that can be applied further to promote healthy eating routines in the working context. However, the findings of these two studies may need to be cautiously interpreted due to the following limitations. Firstly, both user inquiry and user study with EAT@WORK were conducted with a small number of people (54 participants in the online questionnaire, 12 participants in the interview, and 14 participants in the user study), which might not be adequate to quantitatively prove the eating behavior and the acceptance of digital tools in the working context. Secondly, the findings were not representative of office eating characteristics and expected digital tools features globally. Different regions may have very varied working and food cultures (Silva, Vaz De Melo, Almeida, Musolesi, & Loureiro, 2014), so it is valuable to understand experiences and requirements in one particular cultural context. We believe our approach can be used to understand eating-related patterns and behaviors as well as possible expectations of digital tools in the working context in other countries.

3.5 Conclusion and Future Work

In this chapter, we presented one user inquiry as well as one user study with the EAT@WORK mHealth prototype.

Regarding the **qualitative user-centered inquiry study**, it consisted of online questionnaires with 54 respondents and semi-structured interviews with 12 participants. Based on the office context in the Netherlands, we set out this study to understand the determinants of knowledge workers' eating routines, generate design opportunities for healthy eating technologies, and identify strategies to appropriate digital health into the workday eating routines. Our questionnaire results suggested that Dutch knowledge workers decided on workday eating routines mainly due to considerations in well-being, productivity, health, and energy support. Our interview findings indicated that to support healthy eating behaviors at work, digital tools should be designed to enable the user to access health-relevant knowledge, planning and goal setting, involving in-office health programs, and exchanging peer support. Moreover, our data analysis suggested two strategies to apply digital health into the office working context, namely integrating technologies into the working context and providing personalized feedback.

Regarding the **formative user study** of a mHealth app, called EAT@WORK, for promoting healthy eating routines among working-age individuals. Based on the societal context of the Netherlands, we set out this study to identify design considerations for appropriate mHealth technologies in the workday eating routines, as well as to develop and evaluate the related UX features. From our study, we proposed and confirmed that to support healthy eating behaviors at work, mHealth tools should be designed to enable the user to access health relevant knowledge, planning and goal setting, being involved in integrated office health programs, and creating peer support. Applying these considerations into the mHealth UX features could significantly improve user acceptance among working-age individuals. Additionally, our qualitative study results revealed that the eating goal assistant could be generally applied in different working contexts, while the integrated health program might not be very applicable to the teleworking context. Receiving social and knowledge support for promoting healthy eating at work was considered to be an on-demand experience.

These results were discussed and synthesized as design implications, including embedding the mHealth features into the existing workplace infrastructure and creating customized user experiences. We look forward to consolidating and engineering our EAT@WORK prototype with nutritionists and application developers to enable a smooth user experience. Eventually, we plan to conduct a longitudinal field study based on our finalized prototype to examine our design's effectiveness in promoting healthy eating during working hours.

PART II | EXPLORING

In the first part of this dissertation, we began by scoping the existing landscape of technology-based digital tools aimed at promoting healthy eating within the working context. Then, we conducted an inquiry study, including both questionnaires and semi-structured interviews, to gain users' insights into the contextual factors that presently impact individuals' eating practices at work. Our review found the need to develop playful digital tools that integrate dietary self-assessment into working routines and utilize workplace infrastructures to promote healthy eating at work. While the contextual inquiry study highlighted factors influencing working-age individuals' eating practices (including well-being, productivity, health, and energy support) and emphasized the need for digital tools supporting healthy eating at work by providing health-related knowledge, facilitating intake planning and goal setting, encouraging engagement in workplace health programs, and enabling peer support.

Building on the findings from the previous part, in this part, we explored how mobile-based self-reported tools can enhance the positive effects of healthy eating at work. In Chapter 4, we initiated our exploration by investigating an acceptable self-reporting method for working-age individuals during working hours. We conducted a comparison of two mobile self-reported dietary assessment methods (4-hour Recall vs. Food Record) within the Traqq app to monitor food intake during working hours. Our findings revealed that the majority of participants displayed a higher acceptance of the Food Record method due to its flexibility in completion time and lower cognitive load. Furthermore, participants commonly suggested integrating digital tools into their daily routines and designing self-reported tools with simple and playful usability. These insights served as the foundation for developing and evaluating the NutriColoring toolkit, a food diary that leverages doodling on coloring sketches for reporting and reflecting on everyday intake in the working context (as detailed in Chapter 5).

4 Self-report Approaches

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Sibo Pan, Elske M. Brouwer-Brolsma, Xipei Ren, Steven Vos, Aarnout Brombacher, and Desiree A. Lucassen. (2022). **Record or Recall? Exploring Self-Reported Dietary Assessment Methods for Office Workers during the COVID-19 Work-from-Home Period.** In *Proceedings of Nordic Human-Computer Interaction Conference* (pp. 1-12). ACM.

Abstract

The workplace represents an important venue to influence eating behaviors. Due to the COVID-19 pandemic, the workplace has rapidly shifted from office to home (WfH). In this chapter, two mobile self-reported dietary assessment methods were compared (4-hour Recall vs. Food Record) to monitor food intake for WfH. A within-subject study involving 30 participants was conducted over a 4-week period. We assessed the workload and acceptance of these two methods using questionnaires and follow-up interviews. Results of questionnaires revealed that most participants presented high acceptance of Food Record related to a more flexible completion time and lower mental burden. Based on interviews, we presented a set of design insights to promote WfH healthy eating, including integrating reminders into daily routines, simplifying the tracking process, and adding gaming elements. Then, we discussed design implications, including integrating digital tools into daily routines and implementing simple and playful usage processes to promote healthy eating during the WfH period. The objectives of this chapter are:

- To explore more accepted self-reported dietary assessment between 4-hour Recall vs. Food Record among working-age individuals during working hours.
- To explore and derive possible improvements and design opportunities to apply digital dietary assessment to the working context.

4.1 Introduction

In the Netherlands, full-time office workers (i.e., >36 hours/workweek) commonly spend eight hours per day at work with various eating-related activities (lunching, snacking, etcetera) integrated into their work routines (Jastran et al., 2009). However, studies indicate that 66-91% of office workers experience long working hours, and their tight schedules are associated with reduced attention to (healthy) eating behaviors, such as food choices and irregular eating times/breaks (Lappalainen et al., 1997). In the short term, a poor diet may affect employees' concentration, mood, and productivity (Florence, Asbridge, & Veugelers, 2008; Johnson, Carlson, Veverka, & Self, 2007; Lindseth et al., 2011); whereas in the long term, unhealthy eating behaviors have been linked to the development of overweight, obesity, and a higher risk of chronic diseases (Nyberg et al., 2018).

As the greater availability of high-speed Internet has developed, remote working has grown as a prevalent mode across various contexts (i.e., offices, homes, and other working locations) (Allen et al., 2015). Before the COVID-19 pandemic, remote work, particularly working from home (WfH), was considered an optional practice (Kniffin et al., 2021). However, the global situation changed drastically during the pandemic, prompting the World Health Organization to recommend the implementation of WfH around the world to prevent the spread of the virus. As a result, nearly one-third of the global population found themselves in lockdown situations (Dubey & Tripathi, 2020). In Europe, lockdown regulations led to a rapid shift from office-based to WfH (Kramer & Kramer, 2020). This swift transition presented challenges, especially for office workers who had to adapt without any prior preparation (Galanti, Guidetti, Mazzei, Zappalà, & Toscano, 2021) or enough skills required for remote work, such as time planning skill and work-life balance (Vander Elst, Verhoogen, & Godderis, 2020; B. Wang et al., 2021). To face these challenges, Lopez-Leon and colleagues (Lopez-Leon, Forero, & Ruiz-DIáz, 2020) suggested creating regular daily routines, including daily consistent meal time and structured working routines. Additionally, setting reminders can be helpful in transforming these actions into habits over weeks of routine (Lally, Van Jaarsveld, Potts, & Wardle, 2010). Previous studies have demonstrated that maintaining regular routines could decrease the risk of mental or metabolic disorders among working-age individuals (Maes et al., 2012). In recent times, WfH has transitioned from a discretionary option to a compulsory policy. Understanding the potential advantages and risks of remote in the WfH context is imperative, as it could significantly impact the happiness, job satisfaction, and work-life balance of working-age individuals (Crosbie & Moore, 2004; Putri & Amran, 2021).

The COVID-19 lockdown and the associated shift to WfH have been linked to unhealthy eating behaviors. Research indicated an increased consumption of unhealthy foods, larger portions during main meals, and more snacks between meals (Ammar et al., 2020). Despite having more time for preparing and organizing meals during the lockdown and WfH period (Di Renzo et al., 2020), limited access to daily shopping and heavy working tasks may reduce fresh food consumption (especially fruits, vegetables, and fish) and increase the choice of convenience foods, junk foods, and ready-to-eat foods with high fat, sugars, and salt (Di Renzo et al., 2020). Moreover, current studies on lockdown eating patterns revealed a shift in self-reported eating towards increased overall food consumption and increased snacking in-between meals (Ammar et al., 2020; Sidor & Rzymski, 2020). This shift is attributed to boredom from interruption of the work routine at home or stress from working tasks without a break (Moynihan et al., 2015; ÖZLEM & MEHMET, 2020). While healthy eating behaviors are essential during the lockdown and WfH period, few studies have recently focused on improving eating routines and behaviors. For instance, the WHO offered food and nutritional tips during the lockdown period (World Health Organization, 2020a). A Spanish study (Rodríguez-Pérez et al., 2020) found that providing a healthy diet to study groups could decrease the intake of fried foods, snacks, fast foods, or sweet beverages but increase vegetables, fruits, or legumes during the confinement. Therefore, understanding eating behaviors and promoting healthy eating routines at home should be recognized as a crucial research gap for the lockdown and WfH period.

Moreover, regarding technology-based dietary assessment methods, self-reported methods of recall and record are the most commonly used approaches to subjectively assess dietary intake (Brouwer-Brolsma et al., 2020). In recent decades, an increasing number of mobile applications have been designed to facilitate self-report and daily nutrition tracking for everyday contexts. For example, MyFitnessPal (Under Armour Inc., 2004) and FatSecret (fatsecret.com, 2018) allow users to scan barcodes to determine food intake and portion size. Lee and colleagues (Lee, Song, Ahn, Kim, & Lee, 2017) developed a mobile application called Diet-A for recording dietary intake, providing real-time feedback, and offering information on disease prevention. Eat&Tell (Achananuparp, Lim, Abhishek, & Yun, 2018) is a mobile application designed to facilitate the collection of eating-related data through automated tracking and self-reporting. Although these digital technologies have focused on tracking food consumption and improving eating behaviors, less attention has been paid to promoting healthy eating behaviors and routines during working hours in the WfH context. Thus, more attention should be given to understanding which self-reported dietary assessment method is better accepted during the WfH period for working individuals.

In this chapter, a within-subject study has been conducted to compare two smartphone-based self-reported dietary assessment methods (namely: 4-hour Recall vs. Food Record) to monitor food intake during the WfH period. The 4-hour Recall method invites participants to report their food intake over the previous 4-hour, and with the Food Record method, participants can report their food intake throughout the day. The main contribution of this study is to compare the acceptance of these two methods, which method can help working individuals gain healthy eating behaviors and routines in the WfH context and develop design opportunities for digital tools to stimulate healthy eating during working hours. This study is designed to answer the following two research questions:

> ***Sub-RQ1.1:*** *Whether the 4-hour Recall method is more effective in terms of workload and acceptance than the Food Record method in supporting working individuals to record food intake?*

> ***Sub-RQ1.2:*** *What are the design opportunities of a self-reported digital tool to stimulate working individuals to change their eating behaviors during the WfH period?*

4.2 Related Work

4.2.1 Self-Reported Dietary Assessment Methods

Self-reported dietary assessment methods are commonly used to assess dietary intake. These methods can be broadly categorized into two types: prospective methods (i.e., food record) and retrospective methods (e.g., dietary recall and food frequency questionnaires) (Naska, Lagiou, & Lagiou, 2017). According to a previous review (Ngo et al., 2009), diet recall and food report are the most frequently applied self-reported assessment methods for daily intake. Regarding diet recall, it is a method to generate detailed food consumption during the setting period (e.g., 2-4 hours recall or 24 hours recall) to provide insights into the habitual intake (Brouwer-Brolsma et al., 2020). Regarding food report, it is a real-time monitoring approach to capture a detailed amount of food consumption during the recording period (e.g., a single day) (Brouwer-Brolsma et al., 2020).

With the development of digital tools, mobile technologies such as smartphone applications (i.e., apps) have become widely accessible (Lieffers & Hanning, 2012). Over the past decade, there has been a gradual switch from paper-pencil-based methods to technology-based tools for diet recall and food record (Clarke-Midura & Dede, 2010). For instance, Compl-eat™ (Meijboom et al., 2017) is a Dutch web-based dietary recall tool with an extensive food list that can be easily modified and tailored for specific research needs. FoodLog (Aizawa et al., 2014) is a food recording system that enables users to convert food images into textual reports with the assistance of image retrieval on their smartphones. Evidence showed that the collection of dietary reports via mobile technologies has the potential to be more convenient than paper-based reporting (Hutchesson, Rollo, Callister, & Collins, 2015) and has a greater possibility for stimulating healthy eating behaviors (Zhao et al., 2021).

However, current dietary assessment methods are normally designed for specific settings and populations. For instance, some are developed to assess the dietary intake of children and adolescents (Baranowski et al., 2002; Casperson et al., 2015; Olukotun & Seal, 2015), some focused on helping the overweight population lose weight (Burke, Conroy, et al., 2011; Yon, Johnson, Harvey-Berino, & Gold, 2006), and some others are mainly used for clinical practice among patients (Gans, Hixson, Eaton, & Lasater, 2000; Shriver, Roman-Shriver, & Long, 2010). Therefore, it is essential to adapt and validate dietary assessment methods for use in different settings (e.g., WfH, worksite, and various cultural backgrounds) or with various populations (e.g., healthy individuals and different age groups) (Poslusna, Ruprich, de Vries, Jakubikova, & van't Veer, 2009).

4.2.2 Digital Tools for Healthy Eating Promotion

In the HCI communities, research on healthy eating technologies has mainly focused on promoting healthy eating and encompassing aspects such as eating goal setting, awareness of healthy eating, feedback, and social connectivity. Previous research by Pan and colleagues (Pan, Ren, Vos, & Brombacher, 2021) discovered that mobile applications are often used as practical digital tools for encouraging healthy eating behaviors. For example, MyFitnessPal (Under Armour Inc., 2004) supports healthy eating by relying on associating food ingredients with calories, and some mobile applications (Hartwell et al., 2019; Sysoeva, Zusik, & Symonenko, 2017b) focused on stimulating healthy food choices by allowing users to scan QR codes on food packages and providing food-related feedbacks. In addition, various digital technologies offering new opportunities to improve healthy eating behaviors have been proposed in the past decades. For instance, some devices are designed to track nutritional information while cooking in the kitchen. They could help users gain awareness of food consumption (Chen, Chi, Chu, Chen, & Huang, 2010). Some smart scales, such as Orange Chef (The Orange Chef, n.d.), can integrate with a mobile app to provide real-time insight into nutrition as well as balanced meals. Furthermore, previous research has explored social features as a helpful approach to encourage behavior change. For example, Instagram (C. F. Chung et al., 2017), a social media and online community, can assist users in achieving personal healthy eating goals. Mobile food journaling (Lukoff, Li, Zhuang, & Lim, 2018) can facilitate family support for healthy eating. Even in the worksite, healthy eating behaviors enable users to be stimulated by gamified social competitions (Zhang et al., 2021). This is in line with earlier findings presented by Pan and colleagues (Pan, Ren, Brombacher, & Vos, 2022), which showed that the majority of people anticipated that the promotion of healthy eating at work would be supported by the goal assistant, social influence, integration with physical program, and provision of food-related knowledge. Additionally, image-based digital tools (Bird & Elwood, 1983; M. Nelson, Atkinson, & Darbyshire, 1996) have recently been proposed to simplify the food reporting process regarding estimating nutrition content and portion sizes.

However, only some studies were focused on specific using context (e.g., working context) with dietary digital tools. It also appears to be challenging since little research has been done to investigate the adaptivity of digital tools for promoting healthy eating during the WfH period. The evidence only shows a potential integration of digital tools into specific usage contexts like worksites. Thus, understanding the acceptance of digital tools in the WfH context is necessary to further develop mobile technologies, especially influenced by the COVID-19 pandemic.

4.3 The Study and Method

In this chapter, we used a dietary assessment app developed by researchers from Wageningen University and Research called Traqq (Lucassen, Brouwer-Brolsma, van de Wiel, Siebelink, & Feskens, 2021). As shown in Figure 4.1, Traqq is a flexible dietary assessment tool that facilitates both records and recalls and can be used to collect dietary intake data on one or more prespecified days. For our study, the app was used as a Food Record (i.e., users can enter their food intake throughout the day as shown in Figure 4.1(d)) and a 4-hour Recall (i.e., users are prompted to report their food intake during the previous 4 hours as shown in Figure 4.1(e)). By comparing these two methods, we would like to find an acceptable time interval (4-hours vs. all-day) that can help working individuals stimulate healthy eating behaviors and routines in the WfH context. The evaluation of user experience with Traqq focused on the task load and user acceptance of two dietary assessment methods during the WfH period. Therefore, the NASA task load index (NASA-TLX) (Hart, 2006) and the Unified Theory of Acceptance and Use of Technology 2 questionnaire (UTAUT2) (Venkatesh, Thong, & Xu, 2012) were used as research tools for data collection.

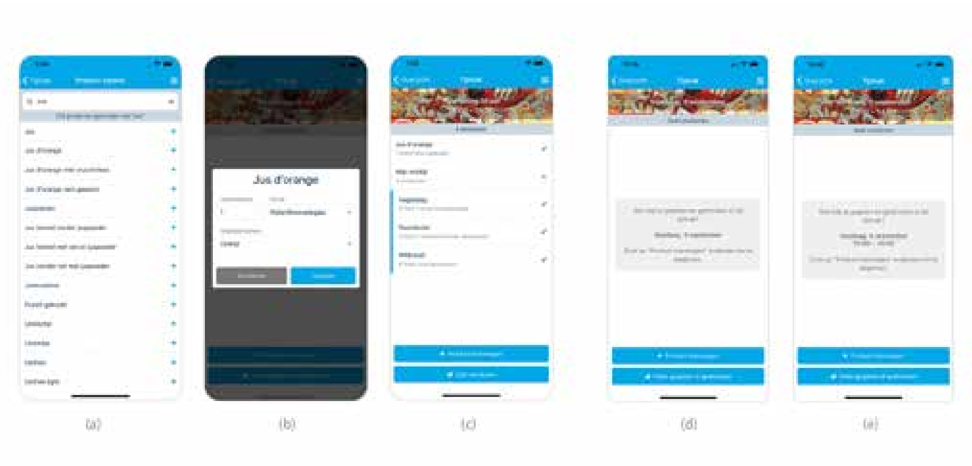

Figure 4.1 Interface of Traqq with functions: (a) selecting food items in the food list; (b) inserting portion size and mealtime; (c) overview of inserted food items and possibility to adjust input. Interface of Traqq with method: (d) Food Record method: report dietary intake throughout the day; (e) 4-hour Record method: report dietary intake over the previous 4-hour (notifications were sent at 10 am, 14 pm, 18 pm and 22 pm in this study).

In response to the research questions, the aim of this study is to 1) investigate and compare the effectiveness and user acceptance of two dietary assessment methods (i.e., 4-hour Recall and Food Record) and 2) explore design opportunities of mobile-based digital tools to stimulate healthy eating behaviors and routines among working individuals in the WfH context. Additionally, we were interested in exploring the user experience of each method to explore further design insights for improvement. According to the review of literature, research questions, and aims of the study, our primary hypotheses are:

H01: The 4-hour Recall method will be a more helpful self-reported dietary assessment tool in the WfH context than the Food Record method.

H02: The 4-hour recall method will be more effective than the Food

record method in terms of workload and acceptance in helping participants record their food intake during working hours at home.

4.3.1 Participants

Thirty participants were recruited by spreading information via word of mouth, using a snowball sampling approach, emails, and social media (Twitter, Facebook, and LinkedIn). To be eligible for inclusion in the study, participants need to meet the following criteria: 1) age between 18 and 65 years; 2) have been working in the Netherlands for more than six months and should be able to speak and read Dutch; 3) be engaged in full-time knowledge work for more than 6 hours a day, five days per week; 4) have a fixed working period every weekday in the WfH context; 5) do not follow a special diet or dietary treatment. Every participant was fully informed of the study procedure with consent without discussing its hypotheses and was able to withdraw at any time. Each participant was compensated €20 in the form of a digital gift voucher after completion of the study.

In total, 32 participants took part in the study. Two participants dropped out of the study in the middle of the process due to personal health status and working schedules. A total of 30 participants aged between 21 and 54 years (M = 31.07, SD = 7.62) finished the entire procedure. Ten participants were male (33.33%), and 20 were female (66.67%). They had worked from 1 to 35 years in an office context (M = 9.41, SD = 9.81). Eighteen participants were Dutch, and 14 participants originated from 12 other countries, including the UK (n=2), India (n=2), China (n=7), and Hungary (n=1). All participants were non-low-income knowledge workers and engaged in a job that requires desk/computer work between six to ten working hours per weekday (M = 7.43, SD = 0.77). On average, most participants worked from home for four days/week (Min = 2, Max = 5, M = 4.03). Ten participants lived alone, whereas 20 lived with families, partners, or friends.

4.3.2 Procedure and Measurements

The study was carried out during the period between October 2020 and July 2021 in the Netherlands. For the study setup, we adopted a within-subject design, where the participants were randomly divided into two groups. As illustrated in Figure 4.2, the study was initiated by an online introductory session via Microsoft Teams to explain the study procedure without discussing the research hypotheses. Each participant was asked to complete a screening questionnaire via Microsoft Form and sign the consent form. The screening questionnaire gathered demographic information, working status, and living status during the WfH period for each participant. Afterward, participants received an introduction with login credentials to access the Traqq app on their smartphones. During the study, participants were asked to report their dietary intake in the app for two whole weeks – once via the 4-hour Recall method and once via the Food Record method – with one wash-out week in between.

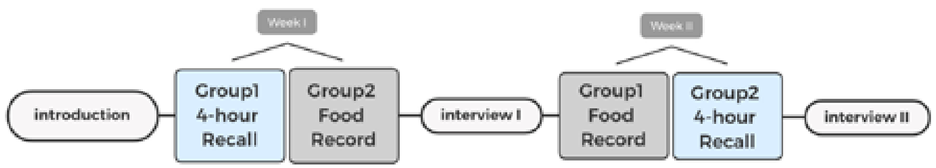

Figure 4.2 A visualization of overall study procedure.

We collected both quantitative and qualitative data (Table 4.1). Quantitative data included results of NASA-TLX and UTAUT2, while qualitative data was gained from follow-up interviews. More details about quantitative and qualitative measurements are explained in the following section.

Table 4.1 Data collected from the study.

Measures	Week I								Week II							
	Day 1	2	3	4	5	6	7		Day 1	2	3	4	5	6	7	
User experience																
NASA-TLX	√	√	√	√	√	√	√		√	√	√	√	√	√	√	
UTAUT2								√								√
Follow-up interview								√								√

Participants received the NASA-TLX (see Appendix B-1) via email every evening in both weeks and had to fill out UTAUT2 after each week. We used NASA-TLX to assess the cognitive workload for both the 4-hour Recall method and the Food Record method. As we mainly focused on examining mental demands, three subscales of NASA-TLX were used in this study – *Mental demands*, *Performance*, and *Frustration* – to indicate how burdensome the participants felt the dietary assessment method was. For each subscale, a lower rating represents a lower workload (1 is low, 21 is high), but in the case of *Performance*, it represents being more satisfied with the performed task (1 is perfect, 21 is failure). The user acceptance of each method was measured by UTAUT2, which included 28 items across eight scales, including *Performance Expectancy*, *Effort Expectancy*, *Social Influence*, *Facilitating Conditions*, *Hedonic Motivation*, *Price Value*, *Habit*, and *Behavioral Intention*. As the Traqq app was not designed for commercial purposes and we mainly focused on testing user acceptance of the 4-hour Recall method and the Food Record method, four scales (*Facilitating Conditions*, *Hedonic Motivation*, *Habit*, and *Behavioral Intention*) were included for further analysis process. Each scale ranged from 1 (strongly agree) to 5 (strongly disagree), with three standing for neither agree nor disagree (as shown in Appendix B-2).

Additionally, the interviews collected qualitative data to identify user experience and further design opportunities for digital tools. After each week, we conducted an approximately 15 minutes follow-up interview to understand participants' experiences and opinions of the 4-hour Recall method and Food Record during working hours, separately. Each interview followed a pre-set protocol and comprised open-ended questions based on the Technology Acceptance Model (Davis, 1989), the Mobile Application Rating Scale (Stoyanov et al., 2015), and the Usability Risk Level Evaluation (Jin & Ji, 2010) (as shown in Table 4.2). We eliminated the same items among these three theoretical frameworks and selected items that suited our research objectives. To conclude the entire study, we asked participants additional questions at the end of the second interview, such as "*Which method of Traqq would you more consider using for your working hours in the WfH context?*" "*Please describe the reason you like or dislike each method and share your ideas for improvement*." and "*Do you have any suggestions concerning the use of Traqq to aid eating activities in your everyday work?*" There was enough space for participants to provide their feedback on their experience. We also asked the participants to explain some interesting statements that emerged during the interviews. Both follow-up interviews were audio-taped and transcribed later for qualitative analysis. The interview data was used to support the interpretation of the quantitative data.

4.3.3 Results

Quantitative Analysis

NASA-TLX and UTAUT2 questionnaire responses were analyzed using SPSS

Table 4.2 Interview pre-set protocol.

Question	Elaborative Question	Theory
1. What do you like/ dislike about Food Record method/4-hour Recall method in the last week?	Does this method fulfil your needs? Why or why not?	TAM-usefulness (Holden & Karsh, 2010); Mobile App Rating Scale (Stoyanov et al., 2015)
2. Are you satisfied with the time taken to track your intake on Traqq with Food Record method/4-hour Recall method?	(Prompts: during working hours/weekend) Does the notification(s) help you remember to track? What factors influence your satisfaction about using Traqq in the last week?	Usability Risk Level Evaluation (Jin & Ji, 2010)
3. What benefits/ disadvantages did you find from this method? What can be improved? How to improve?	/	/
4. What customization features about Food Record method/4-hour Recall method would you like to see on Traqq?	(Prompts: (un)desired functions/features)	Mobile App Rating Scale (Stoyanov et al., 2015)

software (SPSS, IBM Version 26; SPSS, Inc., Chicago, IL). Initially, the quantitative data was processed with descriptive statistics, in which the distribution of the NASA-TLX and UTAUTS data were checked through Shapiro–Wilk tests. For data with normality, we conducted Paired-Samples *t*-tests with the methods (4-hour Recall and Food Record) as a factor. For the data that was not normally distributed, we conducted a Wilcoxon Signed-ranks test to measure the difference between the two methods. The main objectives of our quantitative analyses were to 1) evaluate dietary intake quality of both Food Record reporting week and 4-hour Recall reporting week and 2) evaluate task load and user acceptance of two methods on Traqq in the WfH context.

Qualitative Analysis

After each study week, approximately 15-minute follow-up interviews were conducted with each participant to collect qualitative data. The interview results were analyzed using MAXQDA software. The thematic analysis (Braun & Clarke, 2006) following inductive coding (Thomas, 2006) was employed for data analysis with the following steps: First, the segmentation of the transcripts was transformed into quote statements and labeled. Then, the labeled statements were measured using affinity diagrams (Kawakita, 1991) to identify recurring clusters with emergent themes. Next, all identified themes and clusters were reviewed, discussed, and revised through several iterations with three research team members to validate the qualitative analysis. The qualitative analysis aimed to gain insight into the use of digital tools to promote healthy eating, determine the adoptive assessment (4-hour Recall or Food Record) for the working context, and explore more insights into design opportunities for digital tools and features.

4.4 Results

4.4.1 Quantitative Analysis

NASA-TLX

The NASA-TLX was used to measure the daily workload of each dietary assessment method during the two individual weeks. Figure 4.3 and Table 4.3 show the results of the NASA-TLX. Participants finished the NASA-TLX over seven days each week with three subscales: *Performance*, *Mental Demand*, and *Frustration*. As shown in Figure 4.3 (a), the perceived load of using both methods scored low (1 is low, 21 is high), resulting from relatively high satisfaction with performance and low levels of mental demand as well as frustration in all conditions. Participants rated the workload with the Food Record method (M = 9.94, SE = 0.29) significantly (p = 0.004) lower than with the 4-hour Recall method (M = 10.67, SE = 0.31).

Regarding the *Performance* (shown in Figure 4.3 (b)), participants perceived a better experience in using the Food Record method (M = 10.75, SE = 0.40) than with the 4-hour Recall method (M = 11.10, SE = 0.38). A Wilcoxon Signed-ranks test indicated that there was no significant difference between the two methods (p = 0.325). Regarding the *Mental Demand* (as shown in Figure 4.3 (c)), the 4-hour Recall method (M = 10.70, SE = 0.34) required a significantly (p = 0.049) higher cognitive load than the Food Record method (M = 10.02, SE = 0.32). Regarding the *Frustration* (shown in Figure 4.3 (d)), we observed that participants' frustration with the Food Record method (M = 9.05, SE = 0.33) was significantly (p = 0.003) lower than with the 4-hour Recall method (M = 10.20, SE = 0.39).

The analysis also showed that the fluctuation in the results of the 4-hour Recall method was relatively large. Specifically, if the participant missed a notification

Figure 4.3 Mean and SE of NASA-TLX..

Table 4.3 Mean values, standard error, and Wilcoxon Signed-ranks test results of NASA-TLX.

	Performance		**Mental Demand**		**Frustration**	
	4-hour Recall	Record	4-hour Recall	Record	4-hour Recall	Record
N	210	210	210	210	210	210
Mean	11.10	10.75	10.70	10.02	10.20	9.05
SE	0.38	0.40	0.34	0.32	0.39	0.33
p	.325		.049		.003	

from the app (e.g., due to a busy working schedule), the score of the NASA-TLX for that day was relatively negative, with low satisfaction with performance and high levels of mental demand as well as frustration. Regarding the NASA-TLX scores during the Food Record week, we noticed a trend of scoring from pervasive low scores (low satisfaction with performance, high level of mental demand and frustration) at the beginning of the week to high scores (high satisfaction with performance, low level of mental demand and frustration) at the end of the week. However, this trend was not significant.

UTAUT2

The data of UTAUT2 was collected at the end of each individual week, which aimed to indicate the user acceptance of the 4-hour Recall method and Food Record method. Figure 4.4 and Table 4.4 show the results of the UTAUT2. Overall, we found that participants were slightly more motivated to use the Food Record method (M = 3.26, SE = 0.10) compared to the 4-hour Recall method (M = 3.36, SE = 0.10) in the WfH context. Specifically, participants had a more positive attitude toward the facilitating conditions to use the Food Record method (M = 2.33, SE = 0.10) in a WfH context than with the 4-hour Recall method (M = 2.68, SE = 0.18). However, they presented disagreements regarding *Hedonic Motivation*, *Habit*, and *Behavioral Intention* for each method. Additionally, a Paired-Samples *t*-test showed that there were no statistical differences between the two methods for the subscales of *Facilitating Conditions* (t (29) = -1.615, p = 0.117), *Hedonic Motivation* (t (29) = -0.328, p = 0.745), *Habit* (t (29) = -0.282, p = 0.780), and *Behavioral Intension* (t (29) = -0.885, p = 0.383).

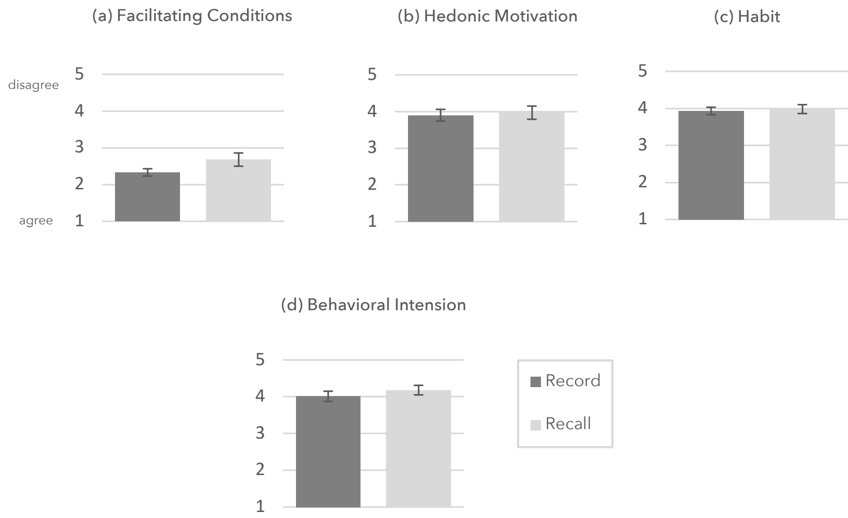

Figure 4.4 Mean and SE of UTAUT2.

Table 4.4 Mean values, standard error, and Paired-Samples *t*-test results of UTAUT2.

	Facilitating conditions		**Hedonic motivation**		**Habit**		**Behavioral intension**	
	4-hou Recall	Record	4-hou Recall	Record	4-hou Recall	Record	4-hou Recall	Record
N	30	30	30	30	30	30	30	30
Mean	2.33	2.68	3.90	3.97	3.93	3.98	4.01	4.18
SE	0.10	0.18	0.16	0.18	0.10	0.12	0.14	0.13
t	-1.615		-.328		-.282		-.885	
p	.117		.745		.780		.383	

4.4.2 Qualitative Analysis

Preferred Method in the WfH Context

According to the follow-up interviews after each individual week, the majority of participants expressed a positive attitude toward using the app during their working hours at home. Twelve participants believed the 4-hour Recall and the Food Record made them more aware of tracking their daily intakes, such as eating too many snacks or not consuming enough fruits. Additionally, eleven participants reported attempting to eat regularly after tracking their food intake at home. Regarding the preference for the two methods (4-hour Recall and Food Record), a total of 138 quotes were selected (as shown in Table 4.5). The various opinions and reasons given by participants can be summarized as follows.

Food Record Twenty-one participants preferred the Food Record method for daily intake tracking in the WfH context. The reasons for their choice can be summarized in the following aspects. First, one notification per day could well remind participants effectively without causing extra disturbance. For example, thirteen participants did not use or directly muted their mobile phones during their working hours at home. Thus, one notification could "*be successfully received in the morning* (P8, P22, P29, P31, P32)", "*reduce using pressure and keep using aspiration* (P2, P4, P16)", and "*do not disturb working schedules* (P2, P4, P11, P13, P14, P28, P31)". Second, the Food Record method provided participants with more space and freedom to fill in the content of their daily dietary intake. For instance, some participants mentioned that "*I can use the app whenever I eat something, which doesn't disturb my working agenda.* (P1, P5, P8, P29, P31)" "*I have more time to specify what I eat at my convenience.* (P11, P 19, P22, P31, P32)" and "*I can not only use Traqq to track what I have already eaten, but also can let me make an eating plan for the rest of the day. So, I can be aware of my eating and balance my intake.* (P4, P32)" Additionally, the responses also indicated that these 21 participants did not choose the 4-hour Recall method mainly due to the excessive reminder settings. P1 stated that "*I don't like 4-times notifications every day because the notifications don't suit my working schedule well.*" P23 mentioned that "*I feel stressed when I miss a notification. Most of my energy is used to avoiding missing instead of tracking itself.*"

4-Hour Recall In contrast, nine participants selected the 4-hour Recall method as their preferred method. Those who preferred the 4-hour Recall method stated that the fixed 4-time notifications were easier to follow and well matched their structured working routine. For instance, some participants mentioned, "*I like the reminders. When I receive the notifications, they help me to remember to insert my intake into the Traqq app straightforward.* (P9, P10)" Some participants stated that "*My working routine is fixed. The setting of these four notifications is reasonable and can be integrated into my working routine perfectly.* (P13)" Yet, these participants did not prefer the Food Record method because they would forget to use the Traqq app after switching off the notification. As P26 mentioned that "*One notification in the morning did not help me a lot. I must remember to use Traqq by myself, which distracts my attention from working.*" P30 stated that "*When I am busy, I always forget to fill in my intake into Traqq. And I realize my missing very late in the day, which gives me too much psychological pressure.*"

Design Opportunity of Future Digital Tool

Participants used the app for both weekdays and weekends during this field study. Twenty-seven participants mentioned that they preferred using the app on weekdays at home rather than on weekends. Three participants had no preference. The reason for this choice was that most participants had structured working and eating behaviors on weekdays. It was easier to use for tracking their food intake due to regular routines. For instance, P1 stated, "*I do not check my phone during the*

Table 4.5 Interview findings of preferred method.

	Method	Theme	Frequence	Exemplar Quotations
Using experience	4-hour Recall	Well-structured reminders	19	"*The setting of these four notifications is reasonable and can be perfectly integrated into my working routine.*"
		Excessive reminder settings	42	"*I feel stressed when I miss a notification. Most of my energy is used to avoiding missing instead of tracking itself.*"
	Record	Less use burden during working hours	27	"*I don't like receiving too many notifications during my working hours. One reminder can reduce the using pressure of such app.*"
		Freedom and flexibility of tracking	36	"*I can use the Trapp app whenever I eat something and specify eating content at my convenience.*"
		Forget reporting if miss the notification	14	"*One notification in the morning did not help me a lot. I must remember to use Traqq by myself, which distracts my attention from working.*"

weekend. Besides, I always have lunch at friends' homes or go out. It is hard for me to recognize all ingredients in the dish and insert them into the Traqq." Moreover, a total of 206 quotes were selected (as shown in Table 4.6). Thirty participants gave various suggestions about how to improve the app. According to the interview data, we identified three desired improvements as follows.

Reminder During the interviews, many participants expressed their concerns about missing the 4-hour Recall notifications, or they indicated that the notifications distracted their daily work and increased their psychological burden when they worked from home. Regarding the Food Record method, some participants suggested that they hoped to gain a daily notification at the end of the day rather than in the morning. For example, some participants mentioned that "*When I get the notification in the morning, it reminds me a new day for tracking. But if I have heavy working schedules that day, I forget to use the app totally.* (P1, P5, P16)" and "*I always suddenly realized to use the app when I check my to-do list before I go to bed. So, if I can receive the notification at the end of the day, it would be helpful*. (P4, P8, P19)" Regarding the 4-hour Recall method, participants expected the digital tool could send notifications according to their working schedules and eating routines. For instance, some participants stated that "*I always have structured working routine and eating habits. Although the time setting of notifications on Traqq is reasonable, it doesn't remind me at the time I want it to remind.* (P22)" "*I normally don't eat breakfast, so the notification in the morning is meaningless to me*. (P27)" and "*I use a workout app, which can send me the notification on the time I normally have a break and do exercise. I hope the Traqq app could also send me the notification at the exact time when I do eat*. (P9)"

Motivation Several participants indicated that tracking their food intake helped them be aware of their intake during the WfH period, as they have more food choices and easier access to food at home than in the office. However, being passively motivated to use the app brought them mental burdens and task loads. Therefore, they hoped digital tools could motivate them with interesting and playful approaches in the Wfh context. On the one hand, participants suggested that digital tools could involve playful and gaming features to inspire them to use the digital tool spontaneously. For instance, "*I do not like to check notifications on my phone because too many apps send notifications. If the digital tool could attract my attention by speaking, I would be easier to notice*. (P3)" "*I hope the digital tool could be a game, I can set daily or weekly goals and then get rewards. The process of tracking can be like passing a level in a game*. (P4)" and "*It would be better if the digital tool could be an intelligent friend. I can 'talk to it' about my intake rather than just fill in my data mechanically*. (P22)" Some participants also expressed a well-designed and playful interface. They stated that "*colorful icons*", "*vivid interaction*", and "*more graphic elements*" could better improve their intentions to use the app. On the other hand, regular feedback was expected by most participants. They mentioned that personalized feedback or an overview of their intake would strongly motivate them to use the digital tool for the long term. And the WfH context provides a good setting to display and overview their intake data without concerning about privacy compared to office context. For instance, "*I do care about my daily calorie intake and nutrition balance, so I look forward to a daily overview about my intake*. (P1)" "*I like to plan my weekly recipes in advance. I hope the digital tool could give me some shopping suggestions based on my intake last week*. (P9)" "*I eat a lot of unhealthy snacks during my working hours at home. It could be useful if the digital tool could find alternatives with healthy ingredients*. (P7, P29)" and "*I always eat similar food during my working hours at home. I want the tool to give me more suggestions on how to extend my recipes*. (P24)"

Tracking Process From the follow-up interview, we learned that almost all participants desired a simplified tracking process during their working hours at home. First, 17 participants mentioned that they had similar foods for breakfast and lunch on weekdays at home. Thus, they expected that already-inserted foods could be remembered and grouped by the application, and then they could directly select from the history box. For instance, P21 stated that "*I always eat similar food on weekdays. By remembering my insert, I don't need to fill in manually again.*" Second, 10 participants hoped to build a connection between Traqq and their shopping content. They explained, "*If the digital tool already knows the ingredients I plan to buy, then my tracking task is only to fill in the amount I eat for each meal.*" Third, seven participants looked forward to involving more graphical elements in the digital tool instead of text only. The graphical elements were identified as a beneficial approach to make the searching and inserting process easier and more efficient. For example, P22 stated that "*Reading the food name in the text takes me too much time. I hope the app could add food pictures into the database. This can shorten the searching and inserting time when I use the app.*"

Table 4.6 Interview findings of future design opportunities.

	Method	Theme	Frequency	Exemplar Quotations
Reminder	4-hour Recall	Integrated reminders into working routines	23	"*I have busy schedules daily, and I wish the Traqq app could learn my routine and notify me precisely when I eat.*"
	Record	Backward reminder	18	"*I always realized to track my intake when I check my to-do list before I go to bed. So, if I can receive the notification in the evening instead of the morning, it would be more helpful*."
Motivation	Both	Playful tracking approach	39	"*It would be better if it could be an intelligent friend. I can 'talk to it' rather than fill in my data mechanically......and I look forward to a trakcing game, where the process is to complete playful tasks.*"
		Well-designed interface	17	"*Traqq is functional but needs a more user-friendly interface. I suggest a redesign with colorful icons and engaging interactions.*"
		Regular and personalized feedback	31	"*I do care about my daily balance, so I'd appreciate a daily overview of my intake.*"
Tracking process	Both	Reduce repeated reporting	34	"*It would better if Traqq could remember my historic reporting. Since I always eat similar food content.*"
		Graphical reporting approach	19	"*If the food content is visualized with designed graphics, I can quickly find the right categories and spend less time reporting my intake during work.*"
		Connecting to shopping list	25	"*If Traqq is aware of the types and quantities of foods I purchase, logging my intake would be easier.*"

4.5 Discussion

This chapter aimed to identify whether the food record or the 4-hour recall method would be better suited for office workers to track their dietary behaviors. Overall, participants generally had a positive attitude about using a digital tool to track their daily intake in the WfH context. The data collected from NASA-TLX and UTAUT2 questionnaires indicated a preference for the Food Record method. This finding was also partly supported by the qualitative responses during the follow-up interviews, in which 21 participants stated that the Food Record method was their favorite method because 1) one notification per day could well remind participants without extra disturbing and 2) it provided participants more space and freedom to fill in the content of daily dietary intake. Both quantitative and qualitative results rejected our two hypotheses that the 4-hour Recall method could be better and more helpful in the WfH context. Moreover, the qualitative results from the follow-up interviews provided insights into design opportunities for future digital tools in the WfH context. We summarize them as two design implications: Integrating reminder into WfH routines and Implementing simple and playful using process.

4.5.1 Integrating Reminder into WfH Routines

In daily work routines, participants usually have a fixed working period that integrates structured eating patterns. During working hours at home, however, we found that most participants tended to prioritize their work schedules without regularly checking smartphone notifications. Our study highlighted that notifications could be perceived as disruptive, bringing extra mental workload for many participants. This finding is in line with some previous research indicating the difficulty of returning to a working task after being interrupted by smartphone

notifications (Czerwinski, Horvitz, & Wilhite, 2004). Studies also suggested that higher mental workloads are associated with receiving notifications while focusing on work (Adamczyk & Bailey, 2004; Horvitz, 2001). Consequently, in the WfH setting, the reminders for dietary assessments should not be disabled but rather designed with flexibility to align users' working-eating routines. As proposed by Fogg (Fogg, 2019), linking tasks with existing routines could enhance the acceptance of digital tools.

Furthermore, notifications play a crucial role in increasing the usability of mobile health applications, improving user retention, and facilitating the achievement of dietary behavioral change goals (Woodward et al., 2021). According to our participants' feedback, it is essential to design notifications in digital tools considering the specific context during the WfH period; These notifications should take tailored forms (e.g., text, voice, and ambient light) customized to individual preferences and allow users to personalize their notification settings. This is in line with prior research recommendations. For instance, Muench and colleague (Muench & Baumel, 2017) pointed out that digital triggers should deliver the right type of notification at the correct time, adapting to individual's specific contextual state. Lee and colleague (K. B. Lee & Grice, 2006) suggested that voice-based applications can help users focus on their current working tasks without requiring additional effort with hands or eyes. Easy Nutrition (Alrige & Chatterjee, 2018) is an example of a customized dietary app that highlights nutritional information and value in a clear way for users. Despite these insights, limited attention has been given to the development and research on the usage of mobile dietary tools in the WfH context.

4.5.2 Implementing Simple and Playful Using Process

Traqq is a self-reported application, which took participants some time to report their intake. The tracking approach for both the 4-hour Recall method and the Food Record method is inserting textual information manually. As mentioned by a previous study (Brouwer-Brolsma et al., 2020), the disadvantage of such self-assessment methods is that they have reactivity bias and are intrusive for users. Therefore, digital tools should be designed with simplicity to promote easy and intuitive workflow for self-reporting, in order to support low levels of mental effort and a short time to use. Specifically, participants expressed a desire for the digital tool to autofill their historical intake data, reducing the time needed for repetitive entries. Traqq addresses this need through its 'My Dishes' function, designed for this specific purpose. Users can input all items of a dish and their respective quantities (e.g., a daily breakfast). Subsequently, users can effortlessly retrieve their dish by searching, with individual items automatically populated in the report (Lucassen et al., 2021). This feature streamlines the reporting process further compared to a generic autofill function, enabling users to report an entire dish at once instead of item by item. Besides, participants also suggested integrating shopping plans into the digital tool, particularly for those who prefer making weekly eating plans. However, privacy concerns arise when considering the connection of digital tools to supermarket services. To address this, future designs should incorporate a grocery shopping assistant feature with a focus on privacy protection. In this scenario, users would only need to input the daily intake amounts. This aligns with the broader recommendation from other studies to simplify the usage process of health-tracking technologies. For instance, (Fogg, 2019) highlighted that health behavior change tasks should be simple and offer positive reinforcement to motivate individuals to develop a habit.

On the other hand, many participants presented interest in incorporating game elements into tracking tools to encourage sustained use for a longer term in the WfH context. Suggestions included introducing conversational user-system interactions, such as "*insert intake by speaking*" and "*receiving advice from the system on healthy eating*". Voice is the fundamental means of human communication. Voice-based application were seen as favorable option due to their convenience and data privacy (K. B. Lee & Grice, 2006) and can provide every user with a friendly interface by adding a feeling of natural interaction (Gardner-Bonneau & Blanchard, 2007). For instance, a Home Radio concept was presented by Eggen and colleagues (Eggen, Rozendaal, & Schimmel, 2003) that using sound and light could create pleasant connections among family members by sharing daily experiences such as eating, working, watching television, etcetera. WeightMentor application (Holmes et al., 2019) could provide timely, automated, and personalized feedback, react quickly to users' needs, and make it easier for users to find and search for the information via voice. Moreover, there are some other examples that showcase the creative possibilities within the field of Human-Food Interaction for promoting healthy eating. For instance, Arnold and colleagues (Arnold, Khot, & Mueller, 2018) explored a cooperative VR game aimed at promoting peer-supported eating behaviors. Acknowledging the rise in snack consumption during the WfH period, Park and colleagues (Park, Koo, Cho, & Bae, 2015) proposed a mobile game called Snackbreaker, designed to expose users to the impact of healthy snack choices in an unintrusive approach. Another innovative interface technology is TasteScreen (Maynes-Aminzade, 2005), which enables users to interact by licking the liquid residue of various flavors that drips onto the screen. Besides, some forms of playful interactions, such as daily game challenges and virtual rewards, were also expected by some participants. By integrating these persuasive game designs, digital tools for healthy eating in the WfH context are anticipated to encourage individuals to actively engage in the process of health promotion (Berger & Schrader, 2016; Coulter et al., 2015; Ordovas et al., 2018).

4.5.3 Limitation

The findings of this study may need to be cautiously interpreted due to the following limitations. First, the study was conducted with a small sample size with an imbalanced sex ratio, which might not be adequate to quantitatively prove the 4-hour Recall method and the Food Record method in the WfH context. Second, the findings were not representative of expected digital tool features globally. Different regions may have very varied working cultures and food cultures. It is valuable to evaluate digital tools in one particular cultural context.

4.6 Conclusion

Due to the COVID-19 pandemic, the traditional office setting has rapidly shifted to remote work from home, necessitating an exploration of working-age individuals' eating patterns in this transitional period and design opportunities for health-promoting technologies that can support nutritional health. Based on the societal context of the Netherlands, we set out this study to compare the user acceptance of two dietary tracking methods (4-hour Recall vs. Food Record) and their feasibility to be adopted for the WfH context, as well as to identify design opportunities to appropriate digital tools into the weekday eating routines. The comparisons between the two methods showed participants' positive attitudes toward using dietary assessment methods in the WfH context. Regarding quantitative results, we tested the workload and acceptance of these two methods with NASA-TLX and UTAUT2 questionnaires. Regarding qualitative results, the main reasons for participants' preference were more flexible filling time and lower mental burden with the Food Record method. Additionally, based on responses in the follow-up interviews, we presented a set of design implications for future digital tools to promote healthy eating during working hours, including integrating reminders into daily working and eating routines, simplifying the tracking process, and adding gaming elements into digital tools. The results of this study could be used to design practical dietary assessment and intervention tools. Eventually, we

plan to conduct a longitudinal field study based on a digital tool to examine our design's effectiveness for easily tracking daily intake during remote working hours. Future work could also focus on evaluating dietary assessment in the WfH context, implementing the design implications reported here into a new healthy eating application, and investigating its potential in stimulating eating behavior change for the WfH.

5 NutriColoring

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Abstract

This chapter was motivated by a desire to help working-age individuals gain a better understanding of their daily nutritional intakes with a new self-reported dietary assessment method, because unhealthy eating behavior increases the risks of developing chronic diseases. In this chapter, we present the design and evaluation of NutriColoring, a food diary that leverages Doodling on sketches to report and reflect on everyday diet in the working context. Through a two-week field study involving 18 participants, the usefulness of NutriColoring in facilitating dietary assessment was tested by making comparisons with a typical bullet diary method. Our quantitative results showed that the NutriColoring provided users with improved dietary assessment experience and intrinsic motivations, with significantly low task frustration and high enjoyment. The interview findings presented a high acceptance of employing the NutriColoring in the working context because of its freedom and playfulness in reporting intakes. Our study concludes with a set of implications for designing and developing a Doodling toolkit to support healthy eating behaviors among office workers. The objective of this chapter is:

- To explore a playful self-reported tool with Coloring approach for working-age individuals and develop design opportunities to apply digital dietary assessment into the working context.

5.1 Introduction

The workplace context plays an essential role in influencing eating behaviors among office workers. A typical working-age adult spends up to two-thirds of their waking hours in the working context and consumes approximately a third of their daily food intake at work (Gorman et al., 2013). Given that unhealthy eating behaviors within the working context have been shown to be associated with increased risk of conditions such as diabetes, obesity, and heart diseases (Naessens et al., 2011), the promotion of healthy eating behaviors has been identified as a crucial determinant influencing individuals' overall well-being and health (Hartline-Grafton, Rose, Johnson, Rice, & Webber, 2010; Lima, Costa, & Rocha, 2018). Moreover, after the COVID-19 pandemic, a shift towards remote working across diverse contexts (i.e., office and home office) has grown as a new working mode (Allen et al., 2015). This shift has contributed to unhealthy eating patterns, including increased consumption of unhealthy foods, larger portion sizes during main meals, and more snacks between meals (Ammar et al., 2020). Consequently, the demand for assistance in performing healthy eating activities and reporting daily intake among office workers is on the rise.

Self-reported dietary assessment tools have been increasingly developed (Hipp et al., 2015; Maes et al., 2012) because it has the potential to facilitate automated intake data collection and support analyses with data visualizations (Elsden, Durrant, Chatting, & Kirk, 2017). People engage in self-reporting since it helps them to develop specific self-awareness of healthy nutritional practices (Elsden, Durrant, & Kirk, 2016; Lazar et al., 2015a). Applying automated self-reporting assessment tools in a daily context, however, addresses several issues: (1) absence of personally meaningful insights (Epstein, Kang, Pina, Fogarty, & Munson, 2016), (2) unmanageable maintenance (Harrison, Marshall, Bianchi-Berthouze, & Bird, 2015), (3) limited flexibility in reporting items for individual needs (Kim, Jeon, Lee, Choe,

& Seo, 2017), (4) technological boundaries (Ayobi, Marshall, Cox, & Chen, 2017), etc. These issues partially led to abandoning digital reporting tools over time and switching to paper notes to avoid unintended effects (Epstein et al., 2016; Lazar et al., 2015a). Paper-based dietary tools are capable of mindful self-reporting practices (Ayobi, Sonne, Marshall, & Cox, 2018). The usage of these papery tools can improve flexibility to construct a self-reporting process, satisfy realistic nutritional needs, and help achieve personal eating goals (Lazar, Koehler, Tanenbaum, & Nguyen, 2015b).

Based on user preference for self-reported tools identified in our prior research (Pan et al., 2021), office workers have a predilection for employing tangible supplies to facilitate a creative and playful self-reporting practice rather than depending on mobile applications in their working contexts. In this regard, paper-based tools, like Doodling can afford physical practices like writing, crafting, and sketching to engage users in reporting personal health status (Andrade, 2010). Doodling, as a beneficial and pleasurable tool for personal care to maintain overall health (Coward, 2023), could lower the threshold of self-reporting and increase the interest in reporting personal data (Fernandes, Wammes, & Meade, 2018; Meade, Wammes, & Fernandes, 2019). Recent studies have indicated that the Doodling tools might be advantageous in the daily working context since it is believed to keep focus on primary tasks without affecting attention or raising mind wandering during working hours (Andrade, 2010; Chan, 2012). However, the complex process underlying the decision to adopt or reject any given Doodling tools of dietary self-reporting practices in daily working contexts requires further exploration (Coward, 2023). Thus, we developed our first research question as follows:

> ***Sub-RQ2.1:*** *How can Doodling be designed and leveraged as a self-reported dietary assessment method for office workers?*

Doodling is a creative method to draw and visualize ideas (Meade et al., 2019). Various modalities for Doodling tools designed to enhance self-reporting engagement have been studied extensively. Evidence indicates that the Doodling with Coloring approach should set out to investigate potential health-related activities (Ashlock, Miller-Perrin, & Krumrei-Mancuso, 2018; Burton & Baxter, 2019; Xi et al., 2022) because using colors to visualize nutrition information could be an effective technique for increasing positive understanding of daily food intake (Ursell, 2007). For instance, Deanna (Minich, 2019) pointed out that the concept of Eat a rainbow (i.e., group fruits and vegetables according to their natural colors; people should consume each hue of fruits and vegetables to acquire a range of various vitamins and nutrients that can prevent eating-related diseases) helps people readily relate to the health properties of healthy intake (i.e., fruits and vegetables) and develop a strong sense of self-awareness through colors (Heber, 2004). However, Doodling via the Coloring approach was mostly explored for self-reporting behavioral and physiological anxiety (Ashlock et al., 2018; Burton & Baxter, 2019; Xi et al., 2022). In-depth studies directly examining how office workers perceive Doodling with Coloring approach and react to its use in daily working context are limited (Elsden et al., 2016). Hence, it would be interesting to investigate the effects of a color-based Doodling tool within a working context. To this end, we develop the second research question as follows:

> ***Sub-RQ2.2:*** *Whether and how the developed Coloring-based Doodling method can help office workers engage in self-reporting on daily eating practices?*

In this chapter, we present the design and evaluation of NutriColoring. NutriColoring is a Doodling toolkit with the Coloring approach to promoting the self-reporting practice of daily intake in the working context. To examine the acceptance and intrinsic motivation of using the NutriColoring toolkit, we conducted a two-week field study with 18 working-age individuals. The study was designed as a within-subject experiment, where we compared NutriColoring to a traditional food Journaling toolkit (named NutriWriting in this study). We collected and analyzed quantitative questionnaire data as well as qualitative interview data to gain a deep understanding of the user experience of the NutriColoring toolkit, and then identify design opportunities for the subsequent development of the Doodling via Coloring approach.

The remainder of this chapter is organized as follows. In the next section, we provide a review of related literature on Doodling and coloring approach. Then, in Section 5.3, we described the study method and material regarding the toolkits (i.e., NutriColoring and NutriWriting), study design, and data analysis. In Section 5.4, we reported both quantitative and qualitative results of our study, which lead to a discussion on the findings and limitations, with implications for future work, in Section 5.5 and 5.6. Section 5.7 contains our conclusions.

5.2 Related Work

In this section, we demonstrate two types of related work. First, we give an overview of how self-reported tools are applied to promote healthy eating patterns. Second, we go into the Doodling approach with the use of colors for self-reporting practices, particularly for health and well-being.

5.2.1 Self-Report for Eating Practice at Work

Self-report has been investigated in many fields, for instance, personal information management (Van Kleek et al., 2009), lifelogging (Sellen & Whittaker, 2010), personal informatics (Elsden et al., 2016), applied design methods (Ayobi et al., 2018; Carter & Mankoff, 2005), etc. It is an essentially human expressive practice that involves documenting and organizing daily experiences in an effort to beneficially stimulate health and well-being (Ayobi et al., 2018; Lepore & Smyth, 2002). Self-reporting for assessing food intake has been increasingly examined in the HCI research field (Cordeiro, Bales, Cherry, & Fogarty, 2015; Cordeiro, Epstein, et al., 2015). On the one hand, a convergence of a wide range of digital dietary assessment tools — such as Compl-eat™ (Meijboom et al., 2017), Traqq (Lucassen et al., 2021), and Dutch FFQ-TOOL™ (Molag, 2010) — has made it possible for people to obtain accurate data and receive pertinent feedback (Burke et al., 2005). On the other hand, dietary assessment tools have become a social approach (Lupton, 2014) while helping individuals gain self-awareness of daily intake (Kersten-van Dijk, Westerink, Beute, & IJsselsteijn, 2017). For instance, Monica et al. (Nour, Chen, & Allman-Farinelli, 2019) used reward mechanisms and social media impacts in a self-reporting app to encourage more vegetable intake among young adults. Chung and colleagues (C. F. Chung et al., 2017) indicated that sharing food pictures on Instagram could motivate peers and seek support for adaptive healthy eating behaviors and eating goals.

Several studies have investigated the barriers for users to adopting digital self-reported tools and suggested that digital tools might induce negative feelings or unintended effects, resulting in refusal to use these technologies in daily contexts (Epstein et al., 2016; Lazar et al., 2015a). A survey of the National Health in America (Fox & Duggan, 2013) found that 34% of users use pencil and paper, while 21% use digital technologies for daily self-reporting. The usage of paper-based dietary assessment tools shows a slightly higher adoption rate. The reasons for this situation could be the flexibility of reporting ways on paper, satisfying volatile eating needs, personalizing eating goals, etc. (Lazar et al., 2015b). Also, failing to meet security and privacy requirements leads to choosing paper-based self-reported tools (Epstein et al., 2017).

Moreover, the acceptance of self-reported dietary assessment tools in the working context is an important emerging topic. According to Naska and colleagues (Naska et al., 2017), self-reported dietary assessment can be roughly divided into two categories: prospective methods (i.e., food diary) and retrospective methods (e.g., dietary recall and food frequency questionnaires). The prior research (Pan, Brouwer-Brolsma, et al., 2022) shows that the food diary ensured more flexible self-reporting for office workers to assess their daily intakes than retrospective assessment methods. A growing number of designs have considered facilitating self-report and daily nutrition tracking for the everyday context. For instance, MyFitnessPal (Byrne, 2015) supports healthy eating by relying on associating food ingredients with calories. Eat&Tell (Achananuparp, Lim, Abhishek, & Yun, 2018) is designed to facilitate the collection of eating-related data through automated tracking and self-reporting. By scanning QR codes on food packages, other designs (Hartwell et al., 2019; Sysoeva et al., 2017b) focused on encouraging healthy food choices and providing food-related feedback to users. Although these self-reported tools have focused on tracking food consumption and improving eating behaviors, less attention has been paid to promoting healthy eating patterns and routines in the working context. Also, despite the benefits of using a food diary for self-reporting, office workers still need to catch up in terms of the utilization rate, and the need for a paper-based food diary has not translated into a long-term willingness to use it in daily working routines. There is much scope for considering self-reported tools in the worksite context.

5.2.2 Doodling as Self-Reporting Approach

According to the Oxford English Dictionary, Doodling is "a random scribbling performed by a person while the mind is more or less otherwise applied." Furthermore, earlier studies intended to explore the advantages of Doodling as a viable means of collecting notes and memory retention (Andrade, 2010). Doodling is also a common means and creative form, which has been shown to positively contribute to self-care and self-expression (Stuckey & Tisdell, 2010). Evidence supports that offering engaging ways for people to participate in the reporting process is one approach to promoting self-care (Coward, 2023). Self-care is the ability to actively take care of one's mental, physical, and emotional health. For instance, Liu et al. (Liu, Chen, Lu, Lin, & Chen, 2020) explore new utilizations based on the idea of user doodles for communication and reporting of dietary. Their findings suggested that Doodling might be an enjoyable and effective form of self-care for people to engage in the nutrition and health domain. Prior research also stated that Doodling enables to lead to an improvement in a person's behavior with ongoing reflection (Barnett & Cooper, 2009; Wallace, 2020), which may optimize self-awareness of personal health and overall sense of well-being.

In recent decades, Doodling has been increasingly popularized as a tool for self-expression through coloring books (Coward, 2023). According to prior research, Doodling in art-making form (e.g., drawing and painting) could be a helpful reporting practice for long-term positive effects on health (Stuckey & Nobel, 2010). It gives not only the artist but also the normal population the ability to tell their individual stories visually and internally (Coward, 2023). Compared to telling stories with a text-based reporting approach (e.g., Journaling), Doodling in art form provides a significant improvement in using engagement (Kim & Sherman, 2007), and also plays as a positive psychological way for people to experience enjoyment during the reporting process (John, 2012). For instance, many recent studies (Clark & Dünser, 2012; Muthard & Gilbertson, 2016; Turturro & Drake, 2022) have shown that Doodling on a coloring book for adults was a beneficial medium for self-reporting states, especially for regulating negative feelings. Two types of Coloring approaches were generally used for self-reporting, namely well-designed coloring notebook (e.g., Mandala, a circle made up of various lined forms and patterns on a notebook) and free coloring activity (i.e., people are not given instructions on what to paint on the paper) (Mantzios & Giannou, 2018). Traditionally, it has been argued that there is no difference between these two approaches, but some studies (Curry & Kasser, 2005; H. Taylor, 2016) examined that a well-designed coloring Doodling was a more useful self-reporting form.

On the other hand, color plays a vital role in the food industry in triggering purchasing behaviors and creating important expectations regarding the flavor and visual appeal of food (Spence, 2016; Stich, 2016). Previous studies suggested that self-reporting via the Coloring approach should not only focus on reducing negative affect (e.g., behavioral and physiological anxiety) but also should set out to investigate potential health-related perspectives (e.g., sedentary lifestyle, healthy eating, etc.) through personalization and customization (Ashlock et al., 2018; Burton & Baxter, 2019; Xi et al., 2022). According to Piqueras-Fiszman and colleague (Piqueras-Fiszman & Spence, 2014), altering the color aspects related to food (e.g., color of plateware/container, color of packaging, and color of the context where foods are eaten) can modify people's perception and motivation to choose healthy foods. Among interventions aimed at promoting healthier food choices, the Traffic Light Diet (red for unhealthy, yellow for less healthy, and green for healthy) was widely used in the mHealth domain. For instance, Gabrielle et al. (Turner-McGrievy et al., 2016) integrated a Traffic light diet to help participants reduce the burden of dietary self-monitoring and provide easy-to-understand feedback. Johnson and colleagues (Johnson et al., 2014) evaluated that a food recommendation system based on the Traffic light diet could give consumers tips for healthier food choices when dining out. Aschemann-Witzel and colleagues (Aschemann-Witzel et al., 2013) found that color-coding labels replacing literal labels could increase the consumption of nutritional products. Montagni and colleagues (Montagni et al., 2020) displayed green labels on healthy food items according to the Traffic light diet developed by Leonard et al. and NUTRI-SCORE

(Julia, Etilé, & Hercberg, 2018) to increase healthy food intake in worksites. Regarding the dietary self-reporting approach with colors, the MyPlate app (U.S. Department of Agriculture, n.d.) has developed food categories into five, namely Fruits (in red), Vegetables (in green), Grains (in orange), Protein (in purple), and Dairy (in blue). This application enables users to report daily intake according to corresponding colors, provides an overview of food consumption within colors, and reminds the distance between the user's actual intake and balanced intake reference.

In summary, the evidence shows an excellent opportunity to deploy dietary self-reported tools in the context of the workplace. Compared to digital reporting tools, office workers prefer paper reporting tools to avoid unintended effects at work. However, it is challenging since little research has been done to investigate the adaptivity of paper-based dietary reporting tools for promoting healthy eating in the working context. Moreover, paper-based tools, such as Doodling, could be advantageous for dietary self-reporting at work. Integrating the Coloring approach into Doodling is also suggested to improve the engagement of the entire self-reporting process. The using experience of Doodling in the working context is still left largely unexplored. Thus, understanding the acceptance of paper-based tools like Doodling among office workers is necessary for further development of dietary self-reported tools, especially in the working context.

5.3 Design of the NutriColoring Toolkit

5.3.1 Key Features of the Design

Grounded on the users' demands of self-reported methods identified in our prior research (Pan et al., 2021), we discovered that office workers prefer to utilize tangible supplies for a creative and playful self-reporting practice rather than depending on mobile applications in their working contexts. Other research studies revealed that employing self-reported Doodling (Clark & Dünser, 2012; Xi et al., 2022) and integrating colors to symbolize different food categories (Aschemann-Witzel et al., 2013; U.S. Department of Agriculture, n.d.; Turner-McGrievy et al., 2016) are two acceptable and enjoyable approaches for health-related stimulation. As a result, we designed NutriColoring, a paper-based self-reported toolkit that integrates the Doodling and Coloring approach. The design explores how Doodling and colors could be incorporated and connect working-age users with reports of daily intake by using tangible supplies (i.e., a calendar on the working desk in this study). The aim of the NutriColoring toolkit is to motivate office workers to report and reflect on personal intake patterns in daily working contexts. The NutriColoring toolkit is used as a research probe in this study with two main features:

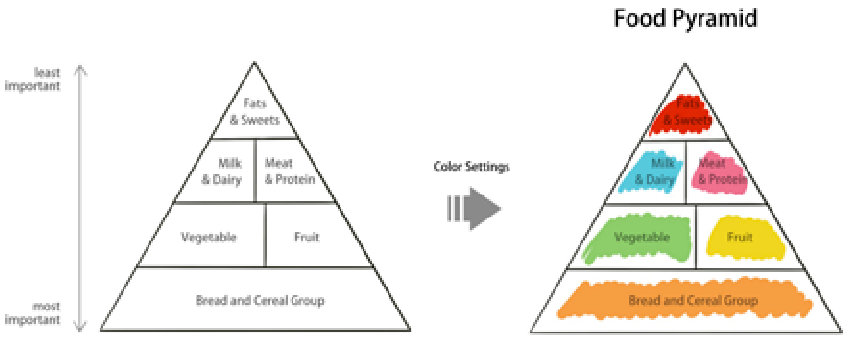


Figure 5.1 Food pyramid and color settings.

- **Doodling based on the Food Pyramid** The traditional triangle-shaped Food Pyramid, initially with six food groups in the 1990s (M. Nestle, 1993) and revised in 2005 (Services, 2005), was later developed into MyPlate in 2011 (U.S. Department of Agriculture, n.d.), featuring only five food groups and excluding the unhealthy food group – Fats, Oils and Sweets – from the pyramid. However, there is evidence indicating that the remote working mode, which includes a shift between office and home office, has led to an increase in the consumption of convenience foods, junk foods, more frequent snacking in-between meals, and an uptake of ready-to-eat foods that are high in fat, sugars, and salt (Ammar et al., 2020; Di Renzo et al., 2020; Sidor & Rzymski, 2020). Therefore, for the design of the NutriColoring toolkit in the working context, we included the Food pyramid (Services, 2005) as a reference. Specifically, four major shelves are included in the Food Pyramid to organize foods (as shown in Figure 5.1). The top shelf is the least important, while the bottom shelf is the most important. Additionally, from top to bottom shelves, the following six food groups are listed: Fats, spreads, and oil; Dairy; Meat and alternatives; Vegetables and salad; Fruit; Bread and cereal food. Inspired by prior research (Burton & Baxter, 2019) that utilized colors for grouping different food categories and easy understanding of nutrition-related information, we designated six comparable colors to each of the six food categories in the NutriColoring toolkit: Orange for grains, Green for vegetables, Yellow for fruits, Blue for milk and dairy, Pink for Meat, and Red (signifies a health risk) for fats, oils, and sweets. The coloring settings of the food pyramid were applied with a group of line-drawing illustrated cards and were then used for Doodling to report intake at work.

- **Doodling based on Well-Designed Illustrations** Inspired by current well-designed coloring tools (Coward, 2023; Mantzios & Giannou, 2018), one member of the research team (the author) created a set of line-drawing cards that were used as coloring aids to make higher engagement during report intake in this study. As shown in Figure 5.2, we designed illustration cards in three categories for Dutch office workers. Three categories were in terms of Dutch Simple Meals (e.g., sandwiches, salads, and fruits), International Cuisine (e.g., Japanese, Chinese, and Italian food), and Fast Food (e.g., pizza, fried chicken, and French fries). These graphic line-drawing cards, which functioned like a coloring book, were used to report users' intake by assigning colors to the specific cards based on the type and quantity of food consumed at work.

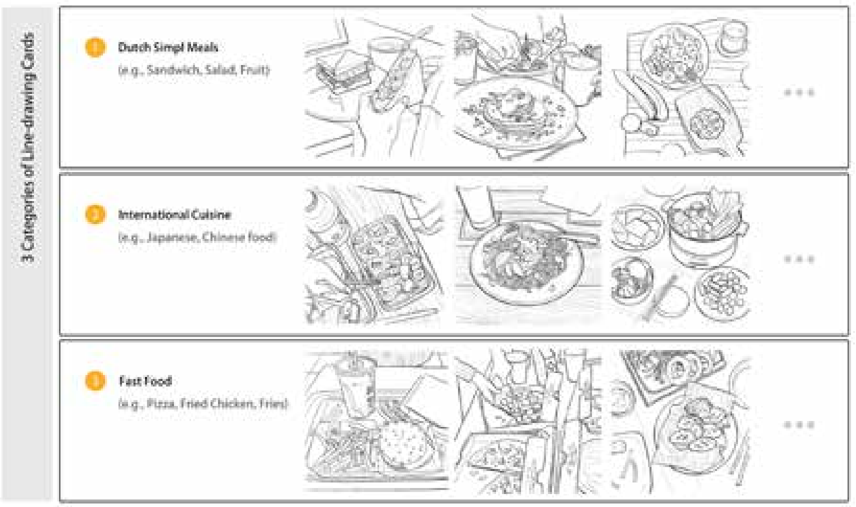


Figure 5.2 Three categories of pre-made line-drawing cards.

5.3.2 Design and Development of the Toolkits

The design of the NutriColoring toolkit was inspired by the design guidelines of the probe toolkit (Sanders & Stappers, 2014). With the combined aims of self-reported Doodling and awareness of healthy intake at work, we identified and developed a typical using scenario for reporting activity with NutriColoring: Coloring your daily

intake as Doodling. This designed toolkit was then put into daily practice as a tangible probe and aimed to promote engaging self-reported Doodling with awareness of individual intake through displaying coloring results. Based on two key features of the design mentioned above, we developed the NutriColoring toolkit with the following content:

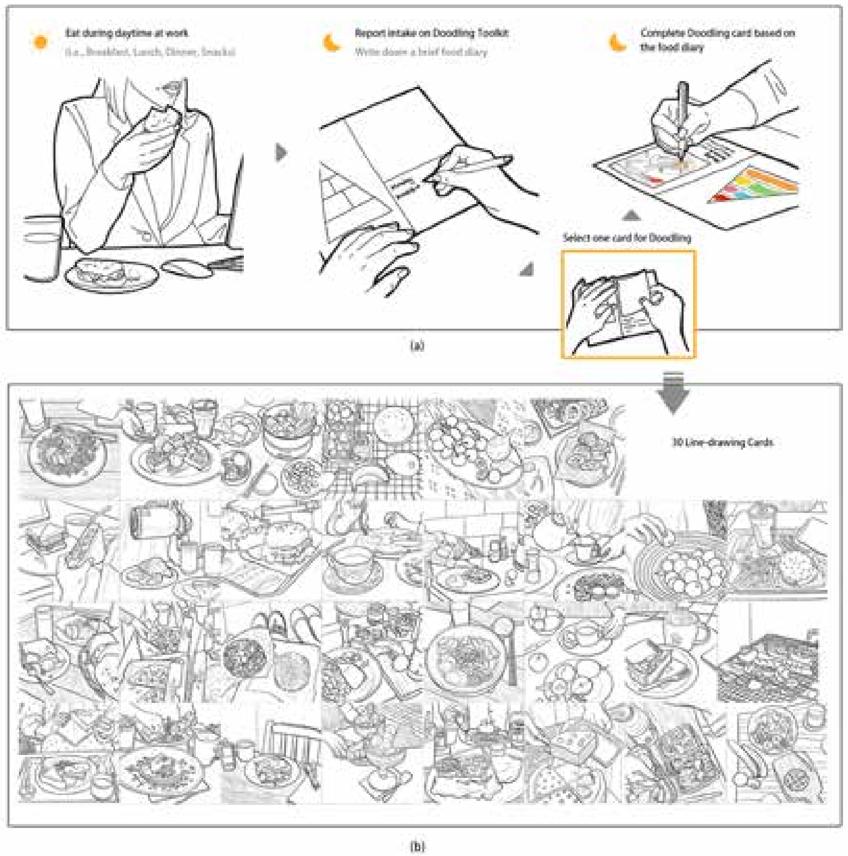


Figure 5.3 Self-reported Doodling Toolkit. (a) Doodling with NutriColoring toolkit; (b) 30 illustrated line-drawings cards for coloring the toolkit.

- **Self-Reported Doodling with Colors** A tangible Doodling calendar that presents the Food pyramid with color settings and contains seven pages for reporting intake at work (as shown in Figure 5.3 (a)). A one-week timeslot for Doodling was chosen, as it aligns with office workers' work schedules and preferences to practice weekly reporting. Besides, after asking and testing the size of each page with participants, 20cm x 15cm was used as the size of the toolkit, since it fits on a working desk without taking up too much space.

- **30 Line-Drawing Cards with Various Meal Types** Thirty line-drawing cards have been designed and developed for this study (see Figure 5.3 (b)). Each day, users could pick one of 30 cards that most accurately reflects their food consumption, and then draw it using six colors categorized by the Food pyramid. The sequence of the colored cards on the Doodling frame may be arranged differently for each user since various users have unique eating patterns.

Eventually, the NutriColoring toolkit (Figure 5.4) has been designed as a box with a one-week Doodling frame, 30 line-drawing cards, six colored pens (orange, green, yellow, red, blue, and pink), and an introduction about how to use the toolkit. Upon receiving the toolkit, users have the flexibility to determine when, how many times per day, and where to use it based on their work routines, schedules, and personal preferences. During the usage of NutriColoring, the user should first write down a brief food diary (i.e., eating time, intake amount of meals or/and snacks) on the doodling frame each day; select one line-drawing card that conforms to their daily intake properly; color the card with pens based on the eating amount of each food categories; stick the card onto the doodling frame; and display the frame on the working desk during the entire study week.

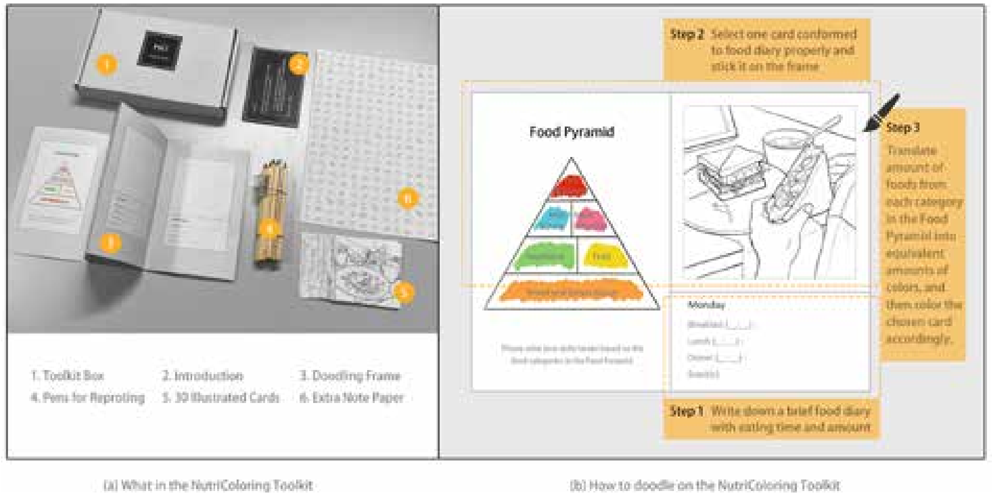


Figure 5.4 Contents of NutriColoring probe toolkits. (a) Items in the NutriColoring Toolkit; (b) How to doodle on the NutriColoring Frame.

To investigate the benefits and to determine the advantages of the NutriColoring toolkit in the working context, we compared it to a writing approach by removing the color-settings of the NutriColoring toolkit. The NutriColoring meant the participants were to draw the doodles on a paper-based probe to illustrate the food intake, while the prompt "writing" meant they were to write out the text-based food intake every eating time. This uncolored toolkit in the form of traditional food Journaling way was named NutriWriting in this study. As seen in Figure 5.5, NutriWriting was created with a page introducing the food pyramid and seven pages for reporting one-worth week of intake while working. The NutriWriting toolkit has one-week Journaling with a pen and an introduction inside the box. While using NutriWriting, the user needs to write down the specific eating time and their intake according to the Food pyramid, and then display the Journaling frame on their working desks.

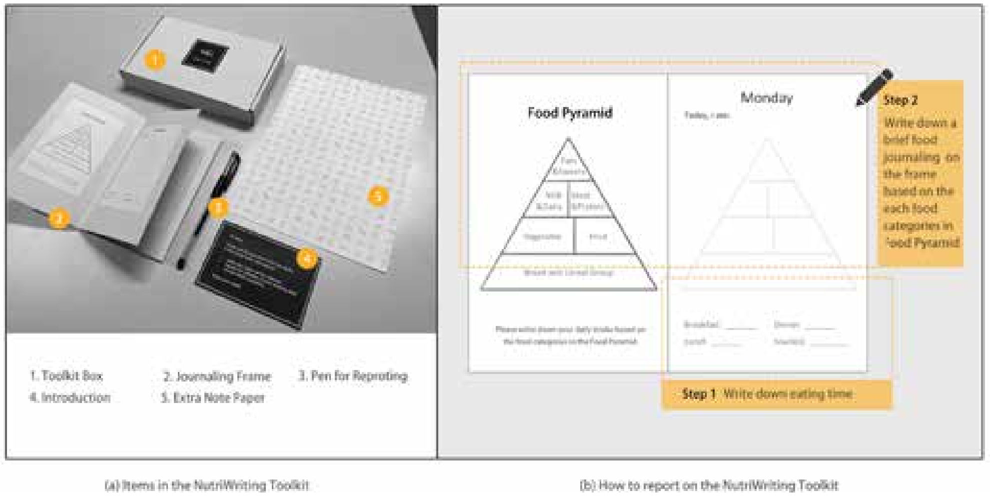


Figure 5.5 Contents of NutriWriting probe toolkits. (a) Items in the NutriWriting Toolkit; (b) How to report on the NutriWriting Frame.

5.4 The Study and Method

In response to the research questions, the objectives of the user study were to investigate (1) the effectiveness of the NutriColoring in facilitating self-reporting of daily intake in the working context; and (2) the role of the NutriColoring in stimulating awareness and self-reflection on daily intake. We used a within-subject design, with participants reporting daily intake at work with two toolkits (NutriColoring vs. NutriWriting) mentioned above. We compared two approaches relating to the user experience from both quantitative and qualitative aspects. Our primary hypothesis is as follows:

H01: The Doodling via Coloring approach (NutriColoring) will be more effective in reporting daily intake at work than text-based food Journaling (NutriWriting).

The participant characteristics, the study procedure, and data collection and analysis are all included in the following sections.

5.4.1 Design and Development of the Toolkits

We recruited participants by spreading information via word of mouth and using a snowball sampling approach. First, we asked people we know who suit our recruitment criteria for the target groups. We then ask them to pass the information to their social contacts via Facebook, Twitter, or other social media like WhatsApp. During the recruitment, we screened participating candidates based on the following criteria: (1) knowledge workers who are engaged in a job that requires desk/computer work for min. 24 hours/week in the office or work from home (due to the COVID-19); (2) do not follow any dietary treatments; (3) are interested in coloring approach but do not have a background in the creative disciplines; and (4) are not color-blind people. They were fully informed of the study procedure before the study weeks and were given the opportunity to withdraw at any time. In total, 20 participants were recruited, and two of them were excluded since they did not have any experience with the coloring approach or work in a fixed place. Finally, 18 participants (gender: 8 males and 10 females, age: M = 29.7, SD = 4.91, Min = 25, Max = 46) completed the entire study. Almost all participants gained a certain educational level (three with bachelor's degrees, 11 with master's, and four with PhD's) and have worked at least half a year (M = 4.64 years, SD = 5.59). Due to the COVID-19 pandemic, they chose hybrid working contexts (work from home and work in an office). Their characteristics are summarized in Table 5.1. We labeled the 18 participants as P01, P02 … P18 in this study.

Table 5.1 Characteristics of 18 participants and their eating goals.

	Gender	Age	Education level	Work years	Work hours/ day	Eating Goal at work
P1	Female	29	Master	2.5	6-8	Healthy eating of non-processed food
P2	Male	32	Master	4.5	6	Gain more protein
P3	Male	29	Master	3	6-8	Gain more weight and protein
P4	Female	26	Master	1	6-8	Diet following 8-16 eating method
P5	Female	26	Master	1.5	6-8	Eat more vegetables and fruits
P6	Female	26	Master	1.5	6-8	Eat healthier and control weight
P7	Male	31	PhD	4.5	8	No heavy lunch
P8	Female	27	Master	0.5	6-8	A balance of different nutrition
P9	Male	25	Master	1	14	Have enough energy to do all tasks
P10	Male	27	Master	1	8	Less processed but nutritional food
P11	Female	46	Bachelor	20	8	Nothing special
P12	Female	29	Bachelor	5	9	Eat nice meals as I like
P13	Male	30	Master	7	8	Keep meat consumption low
P14	Female	31	Master	2	8	Varied-nutrient diet
P15	Female	29	PhD	3	6-8	Eating healthy with more food choices
P16	Male	32	Master	7	8	Nothing special
P17	Male	35	Bachelor	1	8	Low carb diet
P18	Female	25	Master	0.5	8	Eat less fat and sweet

5.4.2 Study Procedure

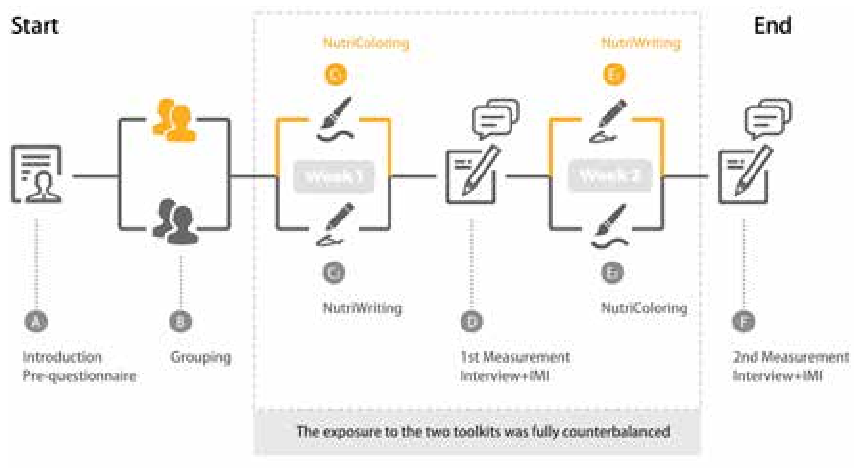


Figure 5.6 A visualization of study procedure.

The cultural probe study was approved by the Ethical Review Board of the Eindhoven University of Technology (reference: ERB2021ID97). We conducted this study in the Netherlands between February and March in 2022. As shown in Figure 5.6, the study initially had an introduction session to explain the study procedure without discussing the research hypothesis. Each participant was asked to sign a consent form and to complete a pre-questionnaire regarding their demographic information, eating goals, and working status. Then, they were randomly given one of NutriColoring and NutriWriting for the first study week and another toolkit for the second study week, with a wash-out week between the two study weeks. The exposure to the two probing packages was fully counterbalanced. Participants were encouraged to maintain their usual eating practices, whether in the office canteen or bring their self-made food. They were given the flexibility to choose when, how often, and where they used the toolkit, aligning with their individual work routines. As part of the research process, participants were required to describe how many minutes they spent using each toolkit and complete the NASA-TLX index (Hart, 2006) daily for the workloads. At the end of each study week, we asked participants to take an Intrinsic Motivation Inventory (IMI) (McAuley, Duncan, & Tammen, 1989) to measure the using experiences of two reporting approaches (NutriColoring vs. NutriWriting). Afterward, we conducted an in-depth interview session with each participant individually.

5.4.3 Measurements

As shown in Table 5.2, we collected both quantitative and qualitative data for two reporting approaches. First, the evaluation of the user experience mainly focuses on mental workload and intrinsic motivation (Deci & Ryan, 2013). In this study, we used NASA-TLX (Hart, 2006), a tool designed for assessing subjective mental workload, to measure the mental workload experienced by participants while using the NutriColoring and NutriWriting toolkits. We maintained two subscales of NASA-TLX related to our study purpose: *Mental demand* and *Frustration* (as shown in Appendix C-1). NASA-TLX aimed to indicate how burdensome the participants felt the reporting approaches during their working hours were, which might negatively influence the engagement in reporting intake. All subscales were rated from 1 to 21; low ratings represent a lower workload. Moreover, the participant's intrinsic motivation to carry out the intake reporting was measured by IMI (McAuley et al., 1989). IMI contains 45 items across seven subscales, which asses self-desire for a specific activity. We selected five subscales due to their high relevance to our study purpose, including *Interest/Enjoyment*, *Perceived competence*, *Pressure/Tension*, *Effort/Importance*, and *Value/Usefulness* (as shown in Appendix C-2). Each subscale should be scored from 1 (not at all true) to 7 (very true).

After each study week, a semi-structured interview was conducted for approximately 30 min per participant to collect qualitative data regarding user experience and opinions on NutriColoring and NutriWriting. The interviews followed a pre-set protocol guided by a qualitative interview technique (Blackstone, 2018) and included open-ended questions about intake reporting and the influence of self-awareness. The questions were set based on TAM-Usefulness (Holden & Karsh, 2010) and Usability Risk Level Evaluation (Jin & Ji, 2010). We keep the questions that suit our research purposes and aims: "*What do you like and dislike about reporting your intake with the toolkit last study week?*" "*Does the toolkit help you to be aware of your intake quality?*" and "*What factors influenced your user experience with the toolkit last week?*" To elaborate on participants' experience with NutriColoring and NutriWriting at work, we then asked them questions such as "*How would you rate your eating practice in the past week?*" and "*Could you please share the stories about your experience related to the reporting approach in the past week?*" We also asked participants to explain more interesting statements that emerged during the interview. All interview sessions were audio-taped and transcribed later for qualitative analysis.

Table 5.2 Data collected from the study.

Measures	Week 1							Week 2						
	Day 1	2	3	4	5	6	7	Day 1	2	3	4	5	6	7
NASA-TLX	•	•	•	•	•	•	•	•	•	•	•	•	•	•
IMI							•							•
Follow-up interview							•							•

5.4.4 Data Analysis

Quantitative Analysis

The NASA-TLX and IMI questionnaire data were analyzed via SPSS software (SPSS, IBM Version 26; SPSS, Inc., Chicago, IL). The quantitative data was processed with descriptive statistics, in which the distribution of the NASA-TLX and IMI data were checked through Shapiro–Wilk tests. For data with normality, we conducted Paired-Samples *t*-tests with the two self-reporting toolkits (NutriColoring vs. NutriWriting) as a factor. For the data that was not normally distributed, we conducted a Wilcoxon Signed-ranks test to measure the difference between the two approaches. The effects of the two toolkits and the day of the study week (from Monday to Sunday) on the workload were also evaluated using a Two-way ANOVA. The main objectives of our quantitative analyses were to 1) test the task load of both NutriColoring reporting week and NutriWriting reporting week and 2) test the intrinsic motivation of the two approaches in the working context.

Qualitative Analysis

The results of the interviews were collected and analyzed via MAXQDA software. The thematic analysis (Braun & Clarke, 2006) following inductive coding (Thomas, 2006) was used for data analysis with the following steps: First, the segmentation of the transcripts was transformed into quote statements and labeled. Then, the labeled statements were measured using inductive coding to identify recurring clusters with emergent themes (Thomas, 2006). Additionally, the analysis of statements was counted to indicate the relevance to our quantitative data. Next, all identified themes and clusters were reviewed, discussed, and revised through several iterations with three members of the research team to validate the qualitative analysis. The purpose of qualitative analysis is to understand the user experience of the self-reported approach with the coloring method compared to the writing approach, and then develop further design opportunities for dietary reporting tools with the Doodling probe (the NutriColoring toolkit).

5.5 Results

5.5.1 Quantitative Findings

Workload

The workload was measured via NASA-TXL with two subscales: *Mental Demand* and *Frustration*. We also asked about using time with each toolkit during the study weeks. Regarding the ***Mental Demand*** (see in Figure 5.7 (a)), reporting with the NutriColoring (M = 9.23, SE = 0.19) was reported to require a higher cognitive load than reporting with the NutriWriting (M = 8.32, SE = 0.18). A Wilcoxon Signed-ranks test indicated that there was a significant difference between the two approaches, z = -2.04, p = 0.042, with a relatively large effect size, r = .48. Regarding the ***Frustration*** (shown in Figure 5.7 (b)), we found that the using frustration with the NutriColoring (M = 7.73, SE = 0.18) was lower than with the NutriWriting (M = 8.20, SE = 0.19). According to the Wilcoxon Signed-ranks test, the differences were insignificant, p = 0.289. Regarding the time consumed for self-reporting approaches (as shown in Figure 5.7 (c)), participants used less time reporting intake with the NutriWriting (M = 4.47 minutes, SE = 0.21, Max = 25 minutes, Min = 3 minutes) than with the NutriColoring (M = 6.26 minutes, SE = 0.29, Max = 16 minutes, Min = 3 minutes). And the Kruskal-Wallis Test showed that there was a significant difference in using time between the NutriColoring toolkit and the NutriWriting toolkit (p < 0.001).

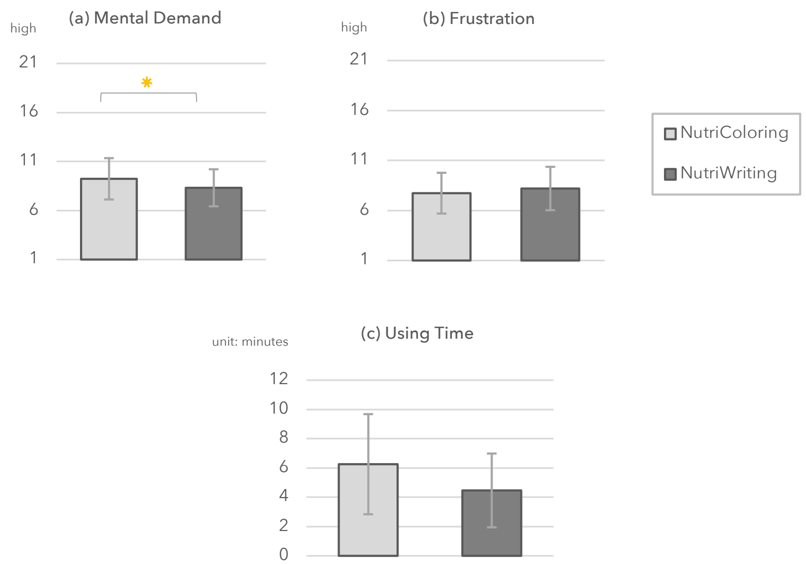


Figure 5.7 Mean and SD of NASA-TLX and Using time with two toolkits.

Besides comparing the average data over the entire study, we also analyze the NASA-TLX scores and task completion durations on a daily basis to understand the changes in workload throughout the study. The two toolkits' separate average daily workloads over the period of a week were calculated for the comparative analysis, and each was shown in a line graph in Figure 5.8 (a). Overall, we found that the mean workload increased while using the NutriColoring toolkit, but the situation was the total opposite when using the NutriWriting toolkit. It was interesting that the workload for NutriColoring began to fall below that for NutriWriting on the third day of the study procedure. Specifically, starting from a relatively higher level of mental demand and reporting frustration (M = 10.50), the figure of NutriColoring then decreased slightly. The average workload of the coloring approach dropped to its lowest point on Friday (M = 5.19) but quickly rose to a high level throughout

the weekend, ending with a mean of 7.93. In contrast, among the 18 participants, the average workload for the writing approach started off lower (M = 7.29) but then increased slightly. Even while it also hit a low point (M = 7.70) on Friday, the scores rose over the weekend, concluding with a mean of 8.52. To determine the impact of toolkits (NutriColoring vs. NutriWriting) and study days (from Monday through Sunday) on workload, a two-way ANOVA was conducted. There was no significant main effect of the two self-reporting approaches on workload, $F = .18$, $p = 0.67$ and no significant difference in study days, $F = .14$, $p = 0.99$.

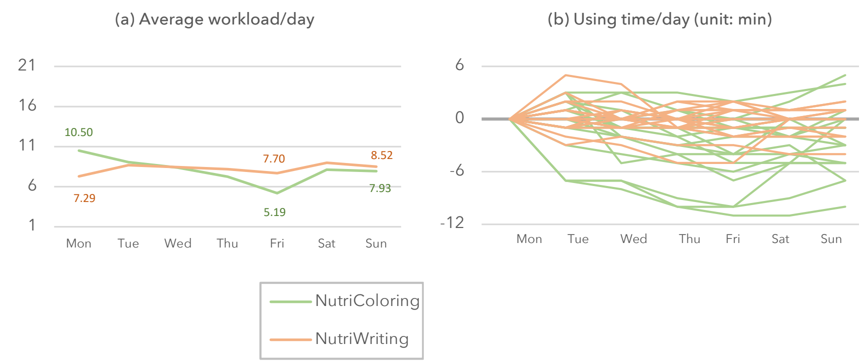


Figure 5.8 Average workload and using time of two toolkits.

On the other hand, we also measured how much time each participant spent each day using two toolkits during the study process. The participant's usage time on the first day of every study week is taken as a baseline. A decrease in the time spent (expressed as negative time costs in the figure) indicates an improved user experience and reduced learning costs. Figure 5.8 (b) illustrates the changes in the time spent using both the coloring approach in a one-week-long period and the writing food diary approach in another week. Compared to the first-day baseline, using time with the NutriColoring toolkit (M = -2.02, SD = 2.76, Min = -8.14, Max = 2.29) showed a gradual decline, while the time with the NutriWriting toolkit (M = -0.12, SD = 1.04, Min = -2.71, Max = 1.14) fluctuated even a little using time reached a peak on the second day. Furthermore, the using time of both toolkits presented a slight climb during the weekends, especially the using duration with the NutriColoring toolkit was increased during weekends.

In summary, self-reporting behaviors with our toolkits scored relatively low in the NASA-TLX workload survey. Reporting intake with the NutriColoring toolkit during working hours required more mental demand but less frustration from participants compared to the NutriWriting toolkit. These results suggest that the use of NutriColoring may play a positive role in enhancing user experience with intake assessment in the working context, which might be used to sustain users' engagement in the long term.

Intrinsic Motivation

Figure 5.9 shows the results of the IMI questionnaire. Overall, we found that participants were positively motivated to report daily intake during working hours, with reasonably high scores on the subscales of *Interest/Enjoyment*, *Perceived Competence*, and *Value/ Usefulness*. Additionally, ratings for these two approaches (coloring vs. writing) were moderate for the subscale of *Effort/Importance* and low for the subscale of *Pressure/Tension*. The quantitative analysis with Paired-Samples *t*-tests showed significant differences in *Interest/Enjoyment*, *Perceived Competence*, and *Effort/Importance* between the two reporting approaches at work.

Interest/Enjoyment Figure 5.9 (a) shows a significant difference in enjoying the reporting process with the Doodling via Coloring approach and the traditional text-based food Journaling (t = 3.491, p = 0.003). The *Interest/Enjoyment* was rated

significantly higher for the NutriColoring (M = 5.01, SE = 0.28) than for the NutriWriting (M = 4.10, SE = 0.23).

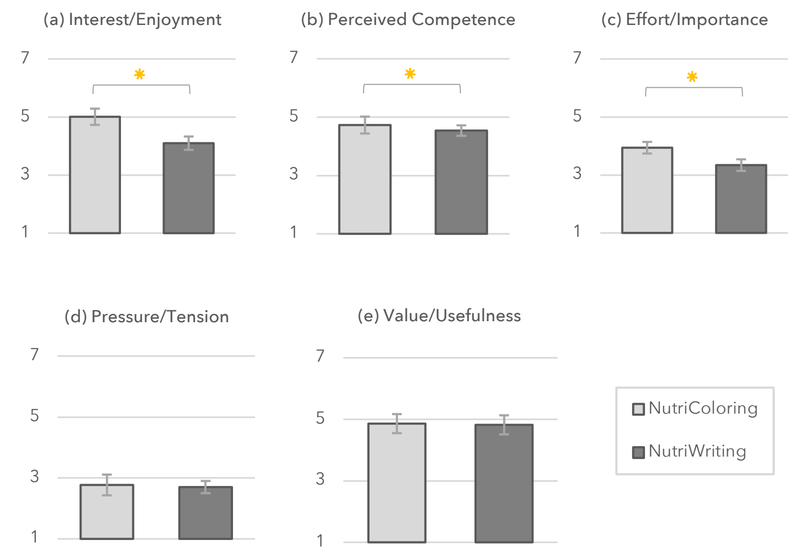


Figure 5.9 Mean and SE of IMI.

Perceived Competence As shown in Figure 5.9 (b), there were significant differences between the two approaches of reporting intake during working hours (t = 2.884, p = 0.010). Participants felt the perceived competence with using the NutriColoring toolkit (M = 5.07, SE = 0.20) was significantly stronger than with the NutriWriting toolkit (M = 4.56, SE = 0.19) while they worked.

Effort/Importance In the *Effort/Importance* subscale (Figure 5.9 (c)), the rates of all participants were significantly different for the two reporting approaches during working hours, t = 2.314, p = 0.033. The intake reporting activity was considered significantly more important with the NutriColoring (M = 3.87, SE = 0.21) than with the NutriWriting (M = 3.31, SE = 0.22).

Pressure/Tension and Value/Usefulness On both two subscales, NutriColoring was rated higher than NutriWriting. However, regarding the perceived tension of the intake reporting at work (shown in Figure 5.9 (d)), there was no significant difference between the NutriColoring (M = 2.77, SE = 0.34) and the NutriWriting (M = 2.70, SE = 0.20), $p = 0.924$. Regarding the perceived usefulness of the intake reporting (as shown in Figure 5.9 (e)), the value of NutriColoring (M = 4.86, SE = 0.31) is slightly higher than that of the NutriWriting (M = 4.82, SE = 0.29). There was also no significant difference between the Doodling and the writing Journaling, $p = 0.660$.

5.5.2 Interview Results

NutriColoring

According to the follow-up interviews, all participants preferred using the NutriColoring toolkit for reporting daily intake in the working context. They explained their reasons for their choice could be summarized as follows.

First, the interview results indicated that most participants expressed a positive attitude toward the playful user experience with the NutriColoring toolkit. They stated that they could see potential benefits of the Doodling with Coloring approach for self-reporting during their working hours and even for long-term use. For example, P4 mentioned that "*It relaxed my mind from work, and I looked forward to using the toolkit every working day.*" Ten participants described the use of the NutriColoring toolkit as "*enjoyable*" and "*interesting*", and six participants described it as "*exciting*".

Second, the responses indicated that the 30 illustrated cards were efficient in motivating a flexible and creative using process and helped protect privacy at work. For instance, P3 explained: "*It strongly encouraged me to enjoy coloring when the illustrated card I chose perfectly corresponds to my daily intake. I also like to select cards in advance and plan my meals with healthy food choices for the following day(s).*" Other participants stated: "*Remembering the food groups and colors is simple. After that, I feel more freedom and less pressure in self-desired drawing ways. For example, a banana in green and orange with meat textures.* (P6)" Participants also mentioned that the flexibility of creation helped to hide their specific intake and protect their privacy in the working context. P5 stated that "*Others cannot understand my cards since they were casual creations and only I know the content in detail.*"

Third, the NutriColoring toolkit was seen as a self-reflection enhancer by the majority of participants. Through collecting images of colored toolkits taken by participants, we noticed that most participants preferred to display colored results in a prominent location on their working desks (as shown in Figure 5.10). For instance, P2 stated that "*It gave me a sense of personal achievements while I put the toolkit on my desk as a piece of art.*" Participants explained that the display of their reporting data could "*provide a clear overview of intake history*", "*compare personal intake with food groups in Food pyramid reference*", "*directly recognize the missing or overeating of a certain food group(s)*", and "*trigger to balance the intake*". P3 also mentioned that: "*Compared to texts, colors are well-visualized feedback, which encouraged me to improve food diversity and keep eating as good as/better than previous days.*" These findings are in line with quantitative results that the NutriColoring toolkit is an interesting and valuable approach for reporting daily intake in the working context.

Figure 5.10 Examples of displaying results of NutriColoring toolkit on participants' working desks.

Additionally, we observed that participants used the NutriColoring toolkit to color their doodles in various ways. In particular, some participants preferred coloring the entire card (as shown in Figure 5.11 (a)), while others (as shown in Figure 5.11 (b)) only colored food-related contents without drawing backgrounds or non-food items (such as dining table and tissues). The doodling results were strongly influenced by each participant's eating habits and food choices. The distribution of color proportions on the same card drawn by different participants can be compared to reveal how each participant's nutritional structure differs. For example, as shown in Figure 5.11 (b), some participants consumed more vegetables (in green), some ate more meat (in pink), and some preferred grain (in orange). Besides, 8 of the 18 participants discovered that, in contrast to NutriWriting's text-based method, colors might visually prompt participants to adjust their food consumption by presenting varied intake amounts for each food category as well as helping individuals spot missing food groups.

However, two participants stated different attitudes toward the NutriColoring. For instance, they demonstrated that "*The Coloring approach requires investing a big effort and time to get awareness of daily intake.* (P1)" and "*It was playful but was a lot for me. I would prefer less stress during the reporting process.* (P15)"

Figure 5.11 Coloring results regarding (a) full-size coloring way and (b) various eating choices among different participants with a same illustrated card.

NutriWriting

Only two participants selected NutriWriting as their preferred self-reporting way during working hours (as shown in Figure 5.12). They claimed that adopting the NutriWriting toolkit made the reporting process simpler to understand, easier to follow, and less using effort, all of which allowed them to maintain their attention on their current tasks. For instance, one participant mentioned, "......*writing was the easier way for me to follow without overthinking, and it was convenient to complete* *unfinished reporting with writing.*" This is in line with our quantitative findings that NutriWriting needs shorter time and lower effort to report intake during working hours. On the other hand, some participants thought that NutriWriting lacked visualized results about their intake. For instance, some participants stated, "*……I gained no valuable information if I only took a glance at the calendar without carefully reading.*" and "*Compared to the coloring calendar, the text-based calendar was not helpful to raise my awareness of intake during my working hours.*" Besides, five of eighteen participants stated that they were concerned about their privacy when they displayed the NutriWriting toolkit on their working desks during the research process because everyone passed by could read and know their data. Moreover, thirteen participants would not like to keep using the NutriWriting toolkit at work for the long term. They predicted the long-term using experience with NutriWriting would be "*repeated efforts*", "*boring*", and "*limited effect*".

Figure 5.12 Examples of displaying NutriWriting results on participants' working desks.

Other Findings

The qualitative analyses also showed that the NutriColoring toolkit and the NutriWriting toolkit can promote reporting intake during working hours in an easy and simple way. The interview responses suggested that the Food pyramid reference enables a new form of understanding food categories and helps report intake efficiently but needs to provide the possibility to encourage participants to achieve personal eating goals. Most participants also experienced a hybrid working context during the COVID-19 pandemic, where a need to design portable products for reporting intake emerged. We elaborated on these findings below, highlighting three other aspects.

Quantify Intake in a Simple Way Although NutriColoring and NutriWriting took the Food pyramid as a reference, most participants stated that it was difficult to quantitatively compare their intake day by day. For instance, P5 mentioned, "*I only draw illustrated food on the card instead of coloring the entire card, because I want to tell the consumptions of each food group by changing the size and area of coloring.*" P2 explained that "*I can tell the amount of intake by seeing the word size and length on the NutriWriting toolkit, but I still look forward to a guideline to tell me whether I eat enough and healthy or not.*" Some other participants suggested that "*It would be beneficial if my the-day-before intake could be my reference, then I can learn if I behave in a better and healthier tendency or in opposite.*" Besides, colored pens in the toolkit were considered as a quantitative tool to promote understanding and decision about intake amount. For example, P4 and P5 stated, "*I thought red (represents fat) is unhealthy, so I put red pen outside the toolkit box and tried to avoid using it.*" P10 mentioned that "*…I always lined up the pens from most to least according to proportions of each food group that day. After that, I just started drawing on the cards, which helped me to realize how much I eat.*" Some participants also suggested that it would be easier to quantify intake at work using stickers or Lego bricks of the same size but in different colors to report intake.

Eating Goal and Behavior Change In the pre-questionnaire, we asked every participant to mention their personal eating goal, and most participants reported a good result in achieving their goals. Instead of finding an eating goal from a scientific institute and dietician, participants showed interest in setting eating goals according to their actual needs and status. For instance, some participants "*plan to eat more vegetables and fruits at work*", some "*try to eat more types of food in one food category*", and some others thought "*less fat, less sweet, and low carbine could help to build up a healthy physical status*". The interview results surprised us that almost all participants were aware of their goals and tried to achieve them during the study process, even though this task was not required for this study. Furthermore, some participants also started to change their eating behaviors by setting doable small steps and challenges. For example, P15 pushed herself to eat two times more fruits than yesterday, and P2 challenged himself to keep regular eating time on a super busy workday.

Hands-On Coloring Tasks within a Hybrid Working Context On the one hand, tangible toolkits also brought hands-on activity in the working context. Specifically, most participants preferred using pens to report intake rather than with mobile applications. They explained that this hand-made approach could help them "*gain an excuse to relax from heavy working schedules*", "*improve retention of intake information*", and "*learn their own eating patterns efficiently*". And displaying toolkits on their working desk was beneficial to remind them to use the tools. However, these findings also showed some potential problems, for instance, "*It was not convenient that I must bring the toolkit with me since I always changed my working place from office to home office.* (P10, P11)" Therefore, participants suggested that it would be a solution to transfer the on-paper approach into a digital application (i.e., tangible tools for reporting, digital application for overviewing intake data and easy to check). On the other hand, according to our quantitative results, the using duration with NutriColoring was increased in the home office context, especially during the weekend. The reasons behind this result were identified as "*high engagement in a private working space with less disturbing from others*", "*more possibilities of coloring the diary while eating*", and "*no judgment about coloring output from others*" by most participants. This finding gave a potential insight into the context that the relative private or/and individual working space enables to motivate the usage of the NutriColoring toolkit. Future design could investigate different working contexts to develop various healthy eating promotions.

5.6 Discussion

This chapter presents the design and usefulness test of the NutriColoring toolkit, a Doodling via Coloring approach that aims to prompt self-reporting and self-reflection about daily intake in the working context. NutriColoring toolkit was designed to support healthy eating at work with two design considerations. First, we integrated the Food pyramid into the NutriColoring toolkit and appropriated food categories with six corresponding colors: Orange (Grains), Green (Vegetables), Yellow (Fruits), Red (Fats, Oils, and sweets), Blue (Milk and Dairy), and Pink (Meat). Second, we explored 30 line-drawing cards with various meal contents to facilitate a color-it-up reporting approach in the working context. A cultural probe study was conducted to understand the user experience of the NutriColoring toolkit compared to the text-based reporting approach (NutriWriting) and test its applicability to workplace healthy eating. We collected quantitative data via NASA-TLX and IMI questionnaires and qualitative interview data with 18 working-age individuals. Our quantitative and qualitative data showed that the NutriColoring toolkit provided users with a positive using experience and motivation in terms of lower frustration and higher enjoyment. The interview results revealed a high acceptance of using the NutriColoring toolkit at work, as participants believed that Doodling via Coloring approach could provide freedom for intake reporting exploration and engagement in intake reporting activities in a playful way at work. Our results and findings confirmed our two research questions that the NutriColoring toolkit could be used for self-reporting at work and positively affects self-reflection about personal eating status. Based on these insights, we further derived several design implications for promoting healthy eating during working hours.

5.6.1 Design Implications

Simple and Interactive Self-Reporting Tools without Overburdening Most participants thought the playful and high-engagement Doodling approach provided by the NutriColoring toolkit design was suitable for relaxation or refreshment in the working context. Based on the colored results display, the NutriColoring toolkit could enable users to self-report daily intake during working hours. Some participants mentioned that the NutriColoring toolkit makes their reporting process occur more frequently because they could easily engage and start the reporting activities spontaneously by coloring a proper illustrated card as a work break. Compared to a text-based journaling tool that requires working-age individuals to record intake repeatedly, NutriColoring based on professional reference (i.e., Food Pyramid) can be easier and more "*work friendly*" to use. Moreover, within the hybrid working context, some participants suggested integrating the self-reporting features of the NutriColoring toolkit into portable digital tools, such as mobile applications or websites, with interactive coloring capabilities. We learned that a digital tool could address issues related to not-at-hand problems due to the switch between the office and the home office, ensuring accessibility. Therefore, future research could explore coloring doodling in digital technologies to make it more adaptive and adjustable. One example could be the use of vision-based sensors, which provide non-intrusive solutions for food monitoring and show promising performance in food recognition, eating behavior detection, intake classification, and food amount estimation (X. Chen & Kamavuako, 2023).

Challenges and Social Triggers for Motivation and Engagement Various studies have examined the impacts of a game challenge mechanism on promoting healthy eating awareness and behaviors. For instance, Peng (Peng, 2009) has suggested that using role-playing and interactive tailoring could increase users' self-reflection on healthy eating as well as their intention to be on a healthy diet. Most participants thought coloring the illustrated cards in the NutriColoring toolkit on each working day enabled them to achieve their personal eating goals step by step unobtrusively. Participants suggested that setting eating goals and daily challenges can positively enhance user experience with paper journaling via the coloring approach, especially the motivation and engagement related to the self-reporting practice. Participants also stated that NutriColoring was easy to learn and performed well with a low learning curve and low mental effort. This simplicity may also lead to boredom and loss of motivation after a few weeks of use. Therefore, for long-term engagement, one possible solution would be to develop the NutriColoring toolkit in a unit social context to facilitate healthy eating via social support. Users in the same workplace with similar eating goals can cooperate or compete via NutriColoring results at work. For example, coworkers with similar eating goals can share coloring results with each other and achieve challenges together; users can present their colored results anonymouslyn to protect privacy; and compare personal data with others to stimulate healthy eating patterns safely.

Personalized and Artistic Achievement In the NutriColoring toolkit, the research team designed illustrated cards with different meal content in advance. These line-based cards may not correspond to every participant's daily intake accurately. Most participants thought personalized cards generated by technical system algorithms or designed by the users themselves would increase using motivation and engagement of self-reporting with the NutriColoring toolkit at work. Additionally, by subclassing colored results in a certain period of time (i.e., one week, one month, and one year), participants looked forward to an artistic overview as feedback, which was considered an efficient method to raise a sense of achievement and help users to report intake with Doodling via Coloring approach in the long term.

5.6.2 Developing the Digital NutriColoring

According to our findings, using the NutriColoring toolkit with the Coloring approach offers working-age users a low-burden and engaging way to self-reporting daily food intake in the working context. In considering the further development of the NutriColoring toolkit, participants stated an opportunity to integrate it into portable digital tools, such as mobile applications and websites. Integrating the NutriColoring from a paper-based tool to a digital version would provide the following advantages: (1) Digital version enables users to engage with NutriColoring across a variety of devices, facilitating easy and frequent use while avoiding the inconvenience of having to carry a physical paper-based toolkit with them. (2) The digital NutriColoring ensures that working-age users can effortlessly transition their dietary intake report between office and home office settings, addressing the challenges associated with the hybrid working context, which is increasingly prevalent (Neumayr, Saatci, Rintel, Klokmose, & Augstein, 2021). (3) Including of personalized and artistic achievement aspects within a digital coloring tool enables users to design their cards or receive algorithm-generated personalized cards. This would not only enhance user motivation but also promote a sense of achievement and sustained commitment to reporting their food intake using the Coloring approach. (4) Digital NutriColoring tool could efficiently manage and store intake data, making it easier for users to gain a visual and real-time data overview and feedback of their intake patterns over time. Evidence showed that data management and storage capabilities are vital to support long-term use and healthy behavior change (Dennison, Morrison, Conway, & Yardley, 2013; Payne, Lister, West, & Bernhardt, 2015). (5) The digital version can facilitate social interactions and support within a community of users with similar eating goals, enabling them to share achievements, collaborate, and compete, which can enhance motivation and engagement of using the NutriColoring toolkit. (6) Lastly, the digital NutriColoring could also be designed to work alongside other health and fitness applications, complementing the move toward comprehensive and integrated health solutions. In conclusion, transitioning the NutriColoring toolkit into a digital version is aligned with the research trends and offers a promising approach to promoting healthy eating practices within the working context.

5.6.3 Limitations and Future Work

The findings of this study may need to be cautiously interpreted due to the following limitations. First, the sample chosen might have influenced the results of the study. For instance, a study with 18 participants may not be adequate to reveal the impacts of the NutriColoring toolkit on healthy eating promotion in the working context. Our sample mainly consists of participants with little to no experience in creative disciplines, which might differ from the experiences of more experienced individuals. Additionally, we specifically selected participants with a high level of education and those who are not color-blind for this study. Therefore, the results may not be representative of the general population when using the NutriColoring toolkit in a working context. Second, our study mainly focused on the usefulness of the NutriColoring toolkit in supporting intake reporting at work for one week, while the desirability of the Coloring approach for long-term and everyday use was not evaluated. For our future work, we will upgrade the NutriColoring toolkit and conduct a long-term field study where the Coloring approach will be used as an everyday gadget in the working context instead of as a research probe for an experiment. Third, another limitation might be the design aspect. In this study, NutriColoring was integrated into a tangible toolkit with pre-set illustrated cards, which may not accurately reflect individual dietary intake content and consumed food amounts. In the future, it will be potential to upgrade the NutriColoring toolkit into digital tools that assist coloring doodling with personalized cards based on individuals' intake content and amount, offering a more simple and efficient reporting approach.

5.7 Conclusion

This chapter presents the design and evaluation of the NutriColoring toolkit, a playful self-reporting Doodling with the Coloring approach for healthy eating at work. In a cultural probe study, we tested the usefulness of the NuriColoring toolkit by comparing it with another traditional food journaling toolkit, NutriWriting. In total, 18 participants were recruited to take part in a two-week study procedure. The main purpose of this study was to investigate the usefulness of the NutriColoring and the potential effectiveness of self-reflection on intake quality. The quantitative data of NASA-TLX and IMI and the qualitative data of follow-up interviews were collected for analysis. Comparisons between the NutriColoring toolkit and the NutriWriting toolkit showed that participants preferred using NutriColoring for self-reporting of intake in the working context because of its lower frustration and higher enjoyment, competence, as well as usefulness. Based on the user responses in the follow-up interviews, we found that: First, interactive and portable self-reported tools would be intuitively designed for exploring the flexibility of dietary assessment within the dual contexts between office and home office. Second, establishing dietary objectives and incorporating them into daily goals could elevate the user's satisfaction when employing a paper journal through the Coloring approach. Third, personalization of line-drawing cards is recommended. These three design opportunities will need to be explored for further design of the NutriColoring toolkit and interactive technologies to promote healthy eating in the working contexts. Besides, to enhance the long-term usage of the NutriColoring, it would be beneficial to implement social strategies such as encouraging colleagues in a shared work environment to collaborate in achieving their eating goals together in the future.

PART III | ENVISIONING

At the end of part I, we noted two main design opportunities to encourage healthy eating at work by capitalizing on the potential of self-reported tools and optimizing the integration between technologies and contextual factors. In part II, our focus shifted towards exploring a design solution and designs that would make self-reported tools for measuring dietary intake during working hours acceptable and playful. Next, in this third part, we look into the future roles of interaction design in facilitating healthy eating practices.

In Chapter 6, we investigate how future users can support designers in generating more creative concepts for food technologies and eating practices. Potential future users can bring valuable expertise through their lived experiences, eating habits, skills, and knowledge, which can inspire designers to develop user-centered concepts. By means of these provocative insights, we introduce a Collaborative Ideation Approach. We aim to involve future users in the design process, thereby challenging or complementing the current digitalization trend and qualification of food technologies, interventions, and tools.

6

Future Eating

Abstract

This chapter presents a Collaborative Ideation Approach for envisioning future eating scenarios and food-tech design concepts in 2040. Using the scenario planning approach, 116 non-design background future users crafted 97 narratives depicting 2040 eating scenarios, inspiring an experimental group of 10 designers to develop 32 concepts of future food technology. In contrast, a control group of 10 designers created 31 concepts without narrative influence. Evaluation by three design experts using the Creative Product Semantic Scale revealed significantly higher creativity in the experimental group's concepts (p = 0.008). Qualitative analysis from interviews with 20 designers confirmed that the narratives positively enhanced the creativity of design concepts for future food technology. This approach bridges the visions of future users with design expertise, fostering creative synergy in envisioning food-tech futures; and highlights the potential for collaborative ideation in future-oriented innovation processes. The objectives of this chapter are:

- To inspire future users to create possible future eating experiences via the Scenario method.
- To explore a collaborative ideation approach between future users and designers.
- To inspire professional researchers and designers in the Human-Food Interaction field to explore future health promotion and food technologies.

6.1 Introduction

Eating is a vital aspect of human life. The developments of digital technologies (e.g., Moley Robotics, n.d.; Berezina, Ciftci and Cobanoglu, 2019; Zhu and Chang, 2020), 3D food printing (Khot, Aggarwal, Pennings, Hjorth, & Mueller, 2017; Sun et al., 2015), virtual reality (Arnold et al., 2018), capacitance sensing (Wang, Li, Jarvis, Khot, & Mueller, 2018; Wang et al., 2020), and genetic mold-arrangement algorithm (Zoran & Cohen, 2018)) in the Human-Food Interaction (HFI) research field have been demonstrated as a potential approach for illuminating new possibilities of how people grow, prepare, cook, eat, dispose, and interact with food (Khot, Lupton, Dolejšová, & Mueller, 2017). In addition, exploring future HFI from an envisioning perspective is an important emerging topic. It appears to be shifting toward an increasing emphasis on factors such as accessibility and imaginability (Grimes & Harper, 2008). For instance, Niijima and Ogawa (Niijima & Ogawa, 2016) proposed a novel method to present virtual food texture by employing electrical muscle stimulation to the masseter muscle; Wang and colleagues (Wang et al., 2017) created a series of 2D edible sheets that can be automatically converted into 3D shapes through hydrating; TastyFloats, introduced by Vi and colleagues (Vi et al., 2017), is a unique taste-delivery system that uses acoustic levitation technology to carry both solid and liquid elements in the air and deliver food morsels directly to users' tongues. Addressing the interplay among humans, food, and technology has been explored at the center of HFI (Altarriba Bertran, Jhaveri, Lutz, Isbister, & Wilde, 2019). The development of experimental future studies extensively implemented in the HFI field might have a significant impact on exploring and articulating the values, desires, imaginations, and possibilities associated with food-tech futures and future eating practices (Dolejšová, Wilde, Altarriba Bertran, & Davis, 2020).

The scenario has received much attention for exploring desires, imaginations, and possibilities for the future because it has the potential to order one's perceptions about an alternative future in which one's decision might be played out, and it emphasizes both forming an accurate picture of the future and encouraging wiser decisions for the future (Schwartz, 2012). Creating narratives is a crucial feature of the Scenario method, which allows individuals to transform the premised materials (e.g., context and type of technologies) into the construction of a future world (Kosow & Gaßner, 2008). Additionally, the narrative-based outputs are easily translatable into design concepts and even solutions (Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006; Markussen & Knutz, 2013), empowering HFI researchers and designers to create new food-tech explorations. Some researchers who worked on future studies (Brown, 1984; Rubin, 1998, 2013) have also noted that narratives about the possible future from the viewpoints of potential users may be useful to not only excite future scenarios but also affect users' current motivations and decisions of adopting HFI technologies (Bell, 2017). Appreciating the richness of viewpoints that the Scenarios method can reveal, we found a chance to investigate how to involve potential user groups to create personal narrative scenarios to explore food-tech futures.

Recently, evidence has shown that asking future potential users to use the capability of the Scenario method to elicit future imaginations may lead to a valuable outcome (Farias et al., 2022). Future users, identified as people without formal training in design, could provide potential insights to designers with a keen understanding of the intended user group and the problem-solving inspirations (Bailey, 2013). For instance, Skirpan and colleagues (Skirpan et al., 2018) invited 22 individuals with computer science backgrounds to understand the technical issues of the current theater environment and to help people with art backgrounds produce an immersive theater show. The development of a collaborative design process can connect future users with designers and thereby accomplish the shift from the traditional designers-based ideation process to a cooperative ideation approach (Shope, 2020; Verhoeven, 2023). These findings indicate that the ideation process underlying the decision to involve future users requires further exploration. In-depth studies directly testing how future users and designers develop design ideations in a sequential process are limited.

In this chapter, we present an approach to supporting a collaborative ideation between future users and designers, exploring a holistic viewpoint of the food-tech futures in 2040. Two sessions were conducted, namely the *Explorative Scenario Session* and the *Ideation Session*. Our contribution is twofold: (1) Our primary contribution lies in a Collaborative Ideation Approach with both future users and designers, offering an alternative way to traditional designer-driven processes and also user-driven processes based on users' experiences in the present world. (1a) ***Explorative Scenario Session***: began with an initial scenario-planning review conducted by the research team, which led to the development of prompts related to food-tech futures to inspire future users and designers. Then, a creation workshop based on the Scenario method engaged 116 future users in generating imaginary narratives about future eating and technologies. (1b) ***Ideation Session***: composing future food-tech concepts by 20 designers. In total, 63 future food-tech design concepts were explored as part of an investigation horizon. Thirty-two concepts drew inspiration from 97 pieces of future scenario narratives written by future users in the previous Scenario workshop, while the remaining 31 concepts were developed independently. Through evaluating all concepts via the Creative Product Semantic Scale (CPSS) metric questionnaire by three design experts, the narratives created by future users could significantly improve the creativity of concepts developed by designers. And the findings of follow-up interviews showed that the Collaborative Ideation process, involving both future users and designers, was effective in expressing a complex and original viewpoint on the innovative future food-tech design process in our study. (2) The secondary contribution is the creation of 97 narratives and 63 design concepts that provide an explorative and holistic horizon of future eating and food-tech innovations in the HFI field.

6.2 Background and Related Work

6.2.1 Food-Tech Future in HFI Research

There is an increasing interest in food within the HFI discipline. Merging interactive technology with food to explore an alternative eating future is one of the essential contributions to the HFI research field (Altarriba Bertran et al., 2019). Regarding HFI research on the food-tech future, numerous workshops have been conducted to explore the diverse roles of technology innovation in everyday eating practices. For instance, a workshop on Designing Recipes for Digital Food Futures (Dolejšová, Khot, Davis, Ferdous, & Quitmeyer, 2018) that focused on future recipes with digital food; Handmaking Food Ideals: Crafting the Design of Future Food-Related Technologies (Dolejšová, Altarriba Bertran, Wilde, & Davis, 2019) tried to highlight human-food automation via data-driven food technologies (e.g., online diet personalization service and AI-based smart food technology) for better future eating experiences; Future of Food in the Digital Realm (Khot, Lupton, Dolejšová, & Mueller, 2017) briefly investigated how food printing technologies could affect our future eating practices and relationship with food; and Fantastic(e)ating Food Futures: Reimagining Human Food Interaction (Davis, Wilde, Altarriba Bertran, & Dolejšová, 2020) contributed to fantastic nourishing ways to technologically support future food practices. These past workshops brought together design researchers, practitioners, and artists to explore diverse imaginations of the food-tech future. However, an interdisciplinary space for more people from varying backgrounds beyond design should be developed and created to discuss HFI future (Deng et al., 2021).

On the other hand, it is essential to stress that an HFI viewpoint on human-food interactions should be taken into an integral and comprehensive manner for future studies (Deng et al., 2021). A successful implementation of the HFI envision depends on raising new approaches and insights in proposing future eating and food technologies. For example, the Feeding Food Futures network (Feeding Food Futures, n.d.) investigates food-tech practices, issues, and opportunities through a food design co-creation approach with various target individuals. And comparing to other studies that provided quick-fix design solutions aimed at convenience, participatory design was suggested as a sustainable practice that opens spaces for creative future food-tech experimentation and a holistic insights into HFI (Dolejšová et al., 2020). These examples showed greater attention to creative design procedures due to increasing interest in a collaboration involving multiple participants, multiple insights, and multiple approaches in the design process.

6.2.2 The Scenario Method for Developing Future Narratives

The Scenario method has been increasingly investigated as a new tool for research and foresight activities during the past few decades. Unlike other techniques for future imagination, the Scenario method is an "open-minded" practice and defined as summaries of future possibilities (Wright, Van der Heijden, Burt, Bradfield, & Cairns, 2008), which mostly aims to unveil the presuppositions and ramifications of current technologies and recount "fantasy technology" embedded in the future (Börjeson et al., 2006). It also connects a future situation with the present while illustrating significant decisions, events, and consequences throughout the narrative (Glenn, 2009). The Scenario narratives do not necessarily have to give in-depth explanations of the future or claim that they are accurate or comprehensive. They can be an interdisciplinary approach to reflect on future issues from users' perspectives (e.g., technological development, pollution of the environment, social structures, and personal health) (K. Anderson & Bows, 2011; Vollmar, Ostermann, & Redaèlli, 2015; Wright et al., 2008). In addition, according to past research, a short to mid-term (around 30 years) forecast is often seen as a scenario with a high possibility and pertinent associated with these future issues because, over a lengthy time horizon, it may turn out to be extremely unlikely relevant to solve the problems (Virdis, 2003). Hence, a period of 30 years is easy and risk-free to create future scenarios based on one's present daily experience.

Regarding Scenario typologies, Börjeson and colleagues (Börjeson et al., 2006) classified three scenario bases: the Predictive scenario, the Explorative scenario, and the Normative scenario. Their intended usage and purpose differ from one another. Compared to the Predictive scenarios and the Normative scenarios that particularly focused on emerging future trends and events and how they may be achieved, the Explorative scenario, however, seeks to explore trends or events that are expected likely to occur, often from a starting point in the future and a variety of viewpoints. It gave people less familiar with future studies an opportunity to get interested in learning about possible innovative consequences (Börjeson et al., 2006; De Smedt, Borch, & Fuller, 2013). The goal of the Explorative scenario is not only to produce design potential technologies but also to explore users' needs and raise users's awareness about technology developments (Rapp, 2020). However, the use of the Explorative Scenario method among future users is still overlooked.

6.2.3 Collaborative Ideation between Future Users and Designers

Evidence showed that future users could provide potential insights to designers via text-based stories with a keen understanding of user needs and the problem-solving inspirations of future technologies (Bailey, 2013). A growing number of studies have considered extending text-based narratives as a usable design material to facilitate collaborative ideation between users and designers for new product development and future innovation (Dahlström, 2019; Parrish, 2006; Välk, Thabsuwan, & Mougenot, 2023). For instance, by conveying customer feedback into stories, Gruen et al. (Gruen, Rauch, Redpath, & Ruettinger, 2002) provided an interesting example of multidisciplinary collaboration among customers, technologists, and product developers to develop new scenarios of future products in the design process. Moon et al. (Moon, Han, & Kwahk, 2019) illustrated that creative storytelling could engage engineers in envisioning futures and generating divergent thinking, contextual comprehension, and innovative interpretations of upcoming technologies, which provided valuable design insights and innovation pathways to designers. Previous studies indicated the value of involving future users in the design process. However, a deeper understanding of the precise role that future users can play and approach to maximize the benefits of collaborative design in developing early design concepts for future innovation requires further explorations.

In summary of the related work, the evidence shows a great opportunity to establish a collaborative bond between future users and designers in an ideation design process. The Scenario method emerged as an advantageous tool for future users to develop narratives envisioning the food-tech futures in 2040, which could reflect their needs from the users' perspectives. The narratives, in turn, could be shared with designers to inform and inspire further user-centered ideation processes. However, it appears to be challenging since little research has been done to investigate the effectiveness of scenario narratives created by future users in inspiring designers to explore design concepts of future eating experiences. Hence, the research question of this chapter is:

> ***Sub-RQ3:*** *How to engage future users and designers in the collaborative ideation process for food-tech futures?*

6.3 The Approach and Material

In this chapter, we proposed a Collaborative Ideation Approach as a research process, combining a range of methodologies, including scenario planning (Ringland & Schwartz, 1998), a creation workshop (Lee et al., 2018), and a co-creation approach (Sanders & Stappers, 2008). It aims to explore a matrix-based framework for providing a potential direction or theme for food-tech futures (Step 1), enable future users to actively participate in the design process by expressing their profound needs through narrative storytelling (Step 2), and engage designers with these narratives in collaboratively generating innovative design concepts envisioning the future of eating and food technology through a co-creation process (Step 3). In light of the Explorative Scenario Planning approach (Planning For Hazards, n.d.) and previous approaches to envision future food and technology from users' perspectives (Olsen, 2015; Wathelet & Minvielle, 2023), the research process of the Collaborative Ideation Approach (shown in Figure 6.1) was visualized as the following outline:

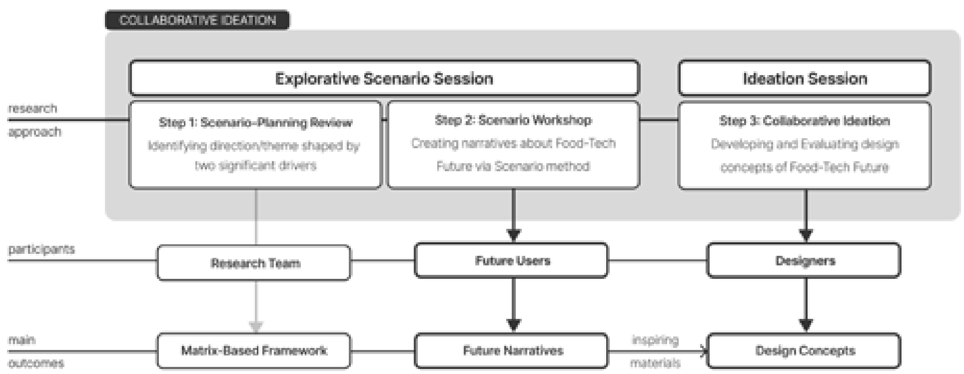


Figure 6.1 A visual outline of the Collaborative Ideation approach, including three steps, participants group, and main outcomes.

6.3.1 Explorative Scenario Session (Step 1 and 2)

Scenario Planning

In general, the future is likely to be shaped by various drivers, which may result in different scenario outcomes (Amer, Daim, & Jetter, 2013). According to the scenario planning method in future studies (Benton, 2019; Ringland & Schwartz, 1998), identifying the two most significant drivers and bringing drivers together into a viable framework are the common steps before building future scenarios. Hence, before the following scenario workshop (Step 2), the research team first conducted an initial review of future eating and food technologies. The initial review was done by the author and one research team member with the following three main steps: (1) First, designs and technologies for future eating were searched in both academic platforms (i.e., ACM digital library and Scopus) and design platforms (e.g., Pinterest, Dezeen, and Future Food Design Awards). The search was conducted using the keywords ("human-food interaction" OR "dietary technology" OR "food technology") AND ("future eating" OR "future food"); (2) Second, the same two members screened all collected results and identified drivers related to the research topic; (3) Third, two significant drivers (*Eating objective* and *Relationship between human and technology*) were selected and illustrated into two axes (Figure 6.2): from *Entertainment-centered* to *Health-centered* (eating objective), and from *People relying on technology* to *Technology empowering people* (relationship between human and technology). A consensus was reached after deliberating the reasons for some discrepancies and discussing them with other co-authors. Additionally, a few exemplars for future scenarios and food technologies from the initial review were provided as samples to understand further scenario building better. Moreover, this two-axe matrix was further used as guidance in the following scenario workshop.

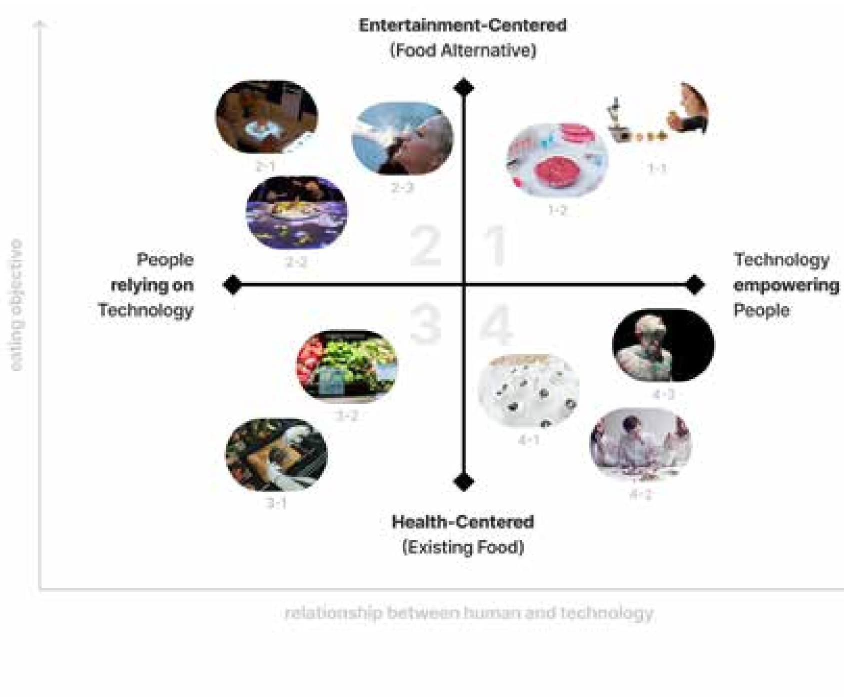


Figure 6.2 The matrix based on two drivers with future scenario exemplars:
(1) Quadrant 1: 1-1 Edible Growth (Rutzerveld, n.d.), 1-2 In-vitro Meat (Bistro In Vitro, n.d.);
(2) Quadrant 2: 2-1 The restaurant of the future (The Restaurant of the Future - YouTube, n.d.), 2-2 Immersive interactive restaurant (TeamLab, n.d.), 2-3 Phora (LIVIN, n.d.-b);
(3) Quadrant 3: 3-1 Moley Robotics (Moley Robotics, n.d.), 3-2 Visualizing the Future of Shopping (Visualizing the Future of Shopping - Vimeo, n.d.);
(4) Quadrant 4: 4-1 Fungi Mutarium (LIVIN, n.d.-a), 4-2 Human Hyena (Gong, n.d.), 4-3 Algaculture (Nitta & Burton, n.d.) .

Scenario Workshop of Food-Tech Future

A workshop based on the Scenario method and motivated by the provocative nature of the Design fiction method (Dunne & Raby, 2013) was conducted at the

Southeast University in China to encourage potential users to create future scenarios regarding food-tech futures and eating practices. The whole process of the workshop ran for approximately 90 minutes.

Participants Inspiring potential future users to imagine future eating scenarios could be beneficial to stimulate possible future actions and influence their current motivations and awareness of healthy eating for their future lives (Bell, 2017). In our study, we engaged with 116 young people in the workshop, aged in their early 20s and studying in the second grade at the Southeast University. All participants came from non-design backgrounds, but their narrative ability led them to the workshop. We also note and anticipate that with different demographics and cultures, the workshop with the Scenario method would take different forms and results (Itenge-Wheeler, Kuure, Brereton, & Winschiers-Theophilus, 2016; J. L. Taylor, Soro, & Brereton, 2018). Finally, based on personal experiences, hopes, and fears for future eating, 116 young participants were invited to imagine food-tech futures with the Scenario method in the workshop. Nineteen of them were excluded due to incomplete scenario narratives (i.e., without a specific explanation of the desired technology and design concept). In total, 97 participants were involved and were named from P1 to P97.

Procedure of the Workshop We briefly explained the Scenario method to the participants and presented two prompts: The first prompt was the framework with two drivers outlined by the scenario planning method (Figure 6.2), which provided a backdrop for participants to envision possible plots, settings, and themes of future eating. The second prompt featured a variety of exemplary scenarios and food-tech innovations, aimed at inspiring future users to be familiar with the framework (Figure 6.2) and get ready to create future narratives.

After the introduction, participants had random pair discussions of the two prompts and developed possible narratives, themes, and technologies. Considering participants' little experience in storytelling and imagination, we suggested a story structure according to previous research (Börjeson et al., 2006; Van Notten, Rotmans, Van Asselt, & Rothman, 2003) regarding *Why* (background settings in 2040), *How* (i.e., future plots and build up a persona), and *What* (a design concept /food-tech future). Also, the provocative nature of Design fiction was used for developing both the beneficial and negative effects of the designed technology. The imagination of future eating could be inspired by the two prompts, the participant's daily experience, and the discussion with others during the workshop. All participants could opt to write narratives in either English or Chinese immediately in the workshop or spend more time arranging the scenes in their heads and get additional inspiration after the workshop. Once the stories were created, participants sent them as PDF files as raw data to the research team.

Data analysis

A total of 116 stories were collected after the workshop, with a word count of 60849 (mean = 524.56, max = 1014, min = 199). An iterative analytical process was conducted: (1) The author and one research team member initially screened 116 collected stories, and 97 stories with in-depth explanations for possible food-tech futures or design concepts were included for further analysis. These 97 stories totaled 51872 words, with a mean of 534.76. (2) Then, content analysis (Stemler, 2000) and word frequency (Silge & Robinson, 2017) were undertaken to identify synthesis scenario themes from the 97 narratives. The same two research team members used Microsoft Excel to transform transcripts into quote statements. One thousand one hundred thirty-seven quotes were categorized under three themes: *Efficiency* (393 quotes), *Entertainment* (354 quotes), and *Ecology* (246 quotes). (3) After that, a thematic analysis following inductive coding (Thomas, 2006) was conducted in each summarized scenario theme separately, which allows categories of 97 narratives to emerge from the raw data itself and leads to the exploration of new ideations. According to the member check approach (Birt et al., 2016), all research team members reviewed, discussed, and revised all identified themes and categories throughout several iterations to emphasize the most significant ones. Then, based on the Co-creation approach (Sanders & Stappers, 2008), all results were provided as inspirational design materials for the *Ideation Session* to explore design concepts regarding envisioned eating experiences and food-tech futures.

6.3.2 Ideation Session (Step 3)

Based on outputs from the *Explorative Scenario Session*, the *Ideation Session* was conducted at the Design and arts school of the Beijing Institute of Technology in China and Eindhoven University of Technology in the Netherlands. Twenty designers were recruited to create at least one design concept regarding food-tech futures and eating practices, and each ideation workshop ran for approximately 140 minutes. After that, all developed concepts were evaluated by three experts in both design research and the food design field, which took approximately 120 minutes.

Ideating Design Concepts for Food-Tech Future

Participants Participants were recruited by social workers through convenience sampling. Inclusion criteria for participation were: (1) designers with more than one year of design experience; (2) good at using digital design software (e.g., Rhino and Photoshop) and tangible design tools (e.g., 3D modeling/mockup and sketching). Participation is voluntary. The participants were informed that they had the right to withdraw from the session at any time without giving a reason and that their information would be kept confidential and anonymous. Written consent was obtained from all the participants. In total, 20 designers (gender: 15 females, 5 males; Age: M = 25.15, SD = 3.29) participated in the *Ideation Session*. They have experience in the industrial design background between 1 and 10 years (M = 3.30, SD = 2.30). All participants were named from D1 to D20 and were randomly divided into an experimental group (D2, D5, D6, D8, D10, D11, D15, D17, D18, D19) and a control group (D1, D3, D4, D7, D9, D12, D13, D14, D16, D20), ensuring a balanced level of design capability/experience between two groups to assess the design outcomes. Moreover, both groups participated in this session with the same process of designing concepts and follow-up interviewing parts. The only difference was that the experimental group was inspired by 97 narratives created by future users (Step 2), while the control group was not.

Procedure of Ideating Design Concepts Before the actual ideation session took place, the participants were informed about the process and asked about their demographics, including age and working experience in the design domain. Regarding the Co-creation (Sanders & Stappers, 2008) procedure of exploring design concepts in the field of food-tech and eating futures (shown in Figure 6.3), the first part involved providing both groups with a similar introduction of the matrix mentioned in Step 1 and three themes (*Efficiency*, *Entertainment*, and *Ecology* defined based on the results of Scenario workshop in Step 2). In the second part, ten experimental group participants received 97 printed narratives, while the control group did not. The only distinction lay in the fact that the experimental group drew inspiration from 97 narratives supplied by future users (Step 2), while the control group did not have access to such narratives. Both groups then had the option to explore design implication(s) separately for each theme within a 90-minute timeframe or spend more time finishing concepts afterward. Once the ideations were created, participants sent them as PDF files as raw data to the research team. The third part was a follow-up interview. The primary questions included: "*What do you think of the idea of creating design concepts with prompts, with/without narratives provided by future users?*" "*What do you like or dislike about the design session process (with/without narratives)?*" and "*What are your main reasons for like/dislike?*" The interviewer probed inductively throughout the data collection process. Most questions were open-ended and started with "*what*" or "*how*" to produce detailed responses. Additionally, participants were asked to rate their experience during the ideation session on a scale from 1 (poor) to 10 (excellent). Each interview lasted around six minutes and was conducted by the first author to ensure a similar approach for each interview and to enhance the consistency of the data collection process.

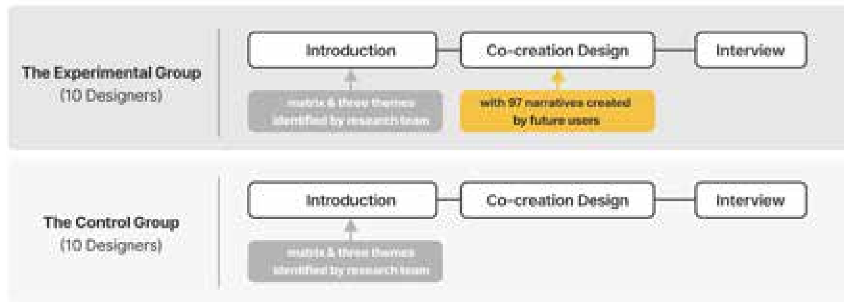


Figure 6.3 Ideating design concepts: the co-creation procedures of the experimental group (with narratives) and the control group (without narratives).

Evaluating Design Concepts for Food-Tech Future

Participants The generated design concepts from the aforementioned ideation sessions were evaluated by three experienced designers (with an average of 14.67

working years, SD = 6.43), two from design research and one from food design expertise. They were invited as evaluators to validate the ideation results developed by 20 designers without informing them whether concepts were created with the assistance of scenario narratives. The experts were named E1 to E3, with an average age of 36.33 years old (standard deviation = 6.11, ranging from 31 to 43 years old); two were female (66.6%), and one was male (33.3%).

Procedure of Evaluating Design Concepts All 63 design concepts were provided to evaluators in a random order via digital PDF files, including the images and text descriptions. The concepts evaluation was conducted with the Creative Product Semantic Scale (CPSS) metric questionnaire created by Chulvi and colleagues (Chulvi, Sonseca, Mulet, & Chakrabarti, 2012). The CPSS questionnaire is a seven-point scale table involving eighteen bipolar pairs of items referring novelty and utility (as shonw in Appendix D), namely *(un)usual*, *(in)operable*, *astonishing/commonplace*, *(non)functional, surprising/customary*, *fresh/overused*, *(un)necessary*, *original/commonplace*, *astounding/common*, *(un)feasible*, *(in)appropriate*, *(un)usable*, *novel/predictable*, *(in)adequate*, *(in)essential*, *useful/useless*, *revolutionary/average*. In the questionnaire, some of the novelty and utility items were reversed to avoid evaluators' inertia. Also, we learned evaluators' opinions and comments on design concepts through objective observations during the entire process.

Data analysis

The qualitative data were audio-recorded and then transcribed verbatim. Transcript data were analyzed by the thesis author using thematic analysis with the MAXQDA software. A grounded theory approach was employed in the analysis process. The coding was an inductive analytic approach (Thomas, 2006). Besides, the quantitative data regarding the evaluation of design concepts via the CPSS questionnaire was analyzed by SPSS software (SPSS, IBM Version 26; SPSS, Inc., Chicago, IL).

First, the data was processed with descriptive statistics, in which the distribution of the CPSS was checked through Shapiro–Wilk tests. For the data that was not normally distributed, we conducted a Wilcoxon Signed-ranks test with the factor (with narratives vs. without narratives) to measure the difference between the experimental group and the control group. The main objective of our quantitative analyses was to evaluate whether narratives created by future users could serve as inspirational materials to motivate designers and improve their creativity of design concepts for food-tech futures.

6.4 Results

We conducted two primary sessions: the *Explorative Scenario Session* (Step 1 and 2) and the *Ideation Session* (Step 3). Regarding the *Explorative Scenario Session*, we initially identified a matrix during the scenario planning review in Step 1. In Step 2, 116 participants actively engaged in creating narratives of future eating and food-tech futures using the Scenarios method. Utilizing thematic analysis and word frequency calculations, we distilled a total of 97 narratives into three distinct themes: *Efficiency*, *Entertainment*, and *Ecology*. These themes formed the foundation for the Ideation Session. In Step 3, twenty designers were invited to explore the potential design concepts for future eating and food-tech innovations. The experimental group with ten designers explored 32 design concepts inspired by the 97 narratives, while another 10 participants from the control group proposed 31 concepts without narratives. Their design resulted in 63 proposed future food-tech concepts that were then tested by three evaluators from design research and the food design domain. Here, we presented the results of both sessions in detail.

6.4.1 Explorative Scenario Session

Data Overview

The results of the content analysis focused on the word frequency task involving the imaginations of the future world and eating in 2040. According to the analysis results, words that refer to eating experience (such as "*Entertainment Industry*" and "*Multi-sensory*"), environment (such as "*Global Environmental Deterioration*"), and eating quality (such as "*Efficiency*" and "*Balanced Nutrition*") were more often presented by participants when describing the future eating in 2040. Then, according to inspired prompts selected by participants and their narratives, the research team collaboratively screened and analyzed the data and then highlighted significant themes into three scenarios: *Efficiency* (n=49), *Entertainment* (n=27), and *Ecology* (n=21).

As shown in Figure 6.4, in each scenario, a summary of the 20 words that were most frequently mentioned was presented as Word cloud. The size of the words represents the relative frequency, with larger words being more frequently mentioned than the smaller words. Moreover, the column diagrams show top ten frequent words in each scenario. Specifically, when participants thought about the future eating for *Efficiency* scenario (Figure 6.4 (a)), the words were associated with "*Balanced nutrition*", "*Robot*", "*Artificial intelligent*", and "*Save time*", and more related to describing the future eating in worksites. In the *Entertainment* scenario (Figure 6.4 (b)), words like "*Multi-sensory*" and "*Virtual Technology*" were addressed, while the future eating for the *Ecology* scenario (Figure 6.4 (c)) was more frequently stated with "*Pollution*", "*Dearth of Food*", and "*Food Alternative*".

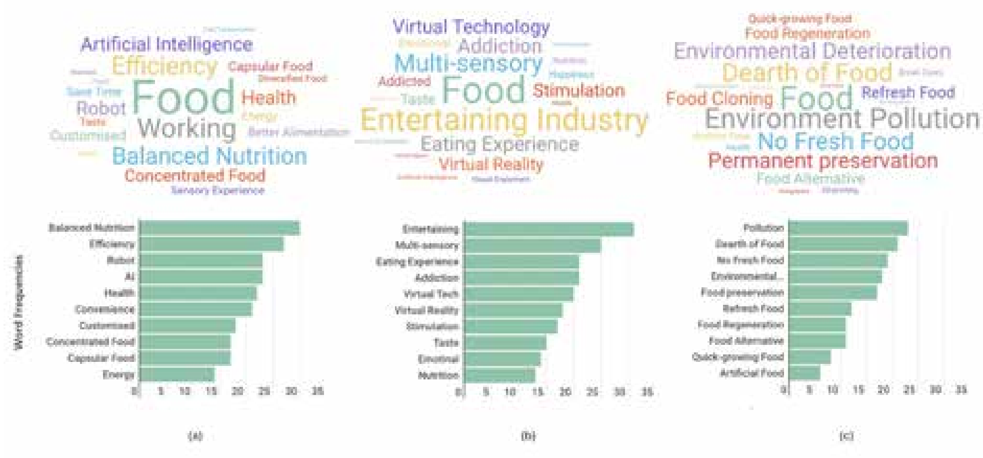


Figure 6.4 Word cloud (top panel) representing the most frequently mentioned words a corresponding 10 most frequent words (bottom panel) for (a) *Efficiency*, (b) *Entertainment*, and (c) *Ecology*.

Thematic Analysis

Scenario 1: Efficiency

Regarding the *Efficiency* scenario, 49 participants described the background in 2040 with the following settings: In 2040, people: (1) get used to working more than 15 hours per day to guarantee social development; (2) attempt to simplify the eating process with concentrated food; and (3) prefer to rely on technology for accurate diet and balanced nutrient intake; (4) give personal eating patterns and health more consideration than societal eating customs. Additionally, the future food technologies in 2040 could be thematically clustered into five types: *Nutrient Concentration* (n=19), *Artificial Intelligence Robot* (n=15), *Redesign of*

Existing Products (n=8), *Virtual Intake* (n=4), and creating *New Mode of Transportation* (n=3).

Nutrient Concentration was expected by 19 participants as future food in future worksites. The majority of people consume nutrition capsules and injections with well-balanced nutrient elements as part of their everyday diet in 2040. P36 stated that "*Technology for food compression is particularly prevalent. Meals may be condensed into tiny capsules while keeping their unique properties like balanced nutrition and taste.*" P19 presented that "*…… one might directly inject the body with the essential nutrients (sugars, amino acids, vitamins, inorganic salts, etcetera).*" Both nutrition capsules and injections are referenced to personal physical data and provide individuals with adequate energy for a single working day. However, long-term use of capsules and injections may have unfavorable effects, such as psychological issues, a decline in chewing ability, and a gradual disappearance of traditional cooking methods.

Artificial Intelligence Robot was defined as mainstream technology by 15 participants in 2040 due to heavy working schedules. With advanced artificial intelligence and 4D-printing technique, these robots are able to prepare delectable and nutrition-balanced food every mealtime by scanning the host's body data regardless of time or location to determine the quality of intake. For instance, P22 hoped that "*The robot cooks nutrient meals after purchasing based on my data and degree of hunger…… food storage and transportation are all handled by robots via food dehydration and recovery technology.*" P42 mentioned that "*Food is scarce in 2040. Based on the rich data in the robotic system, a 4D-printing robot can print three-dimensional edibles with a variety of tastes and shapes to satisfy the human need to eat.*" However, since robots take the job of chefs, human cooking abilities may eventually become extinct.

Redesign of Existing Products is also a trend in 2040 based on eight participants' narratives. People in 2040 concentrate on improving the already available products at workplaces (such as a multipurpose oven and stove) that can rapidly prepare delicious and nutritious meals since they spend too much time at work. For example, P44 mentioned an oven, which "*can synthesize the elements in the air into food and can also automatically sterilize*". P18 hoped that "*A pot has the ability to immediately break down food into little bits. For the meal to be quickly digested by the human body, the pot may eliminate wastes that are worthless to health.*"

Virtual Intake could be a food alternative, according to four participants. They imagined that humans would start charging their bodies like machines or eating virtual energy (e.g., electricity) as food to get energy boosts in 2040. For instance, P33 said that "*The wearable gadget takes the place of the human digestive system. Eating is not the way to get energy; instead, people may charge their bodies.*" And P28 stated a similar concept — "*It is possible to consume a virtual or actual battery like food. It may provide the brain energy, which is a good meal replacement and can significantly increase the productivity at work*." Additionally, P46 desired the technology in 2040 that would allow a direct conversion of text into edible food to help people learn and retain information more efficiently. After eating, people can acquire knowledge without devoting a lot of time to it. Despite having easy access to energy in 2040, the inability to chew and digest food may lead to future generations having unhealthful bodily conditions.

New Mode of Transportation provides working-age individuals with considerable opportunities to eat global foods in seconds, according to three participants' stories. For instance, P25 and P48 hoped that "*Foods can be delivered through the internet in the future, and 3D printer can receive recipes anywhere and print food out for the customers.*" Although such rapid ways of spreading food allow people to eat a variety of foods in a short time, it may reduce the social interaction among people. The lack of emotional communication may cause more psychological problems in 2040.

Scenario 2: Entertainment

Twenty-seven participants created stories for the *Entertainment* scenario. According to descriptions of narratives, the background in 2040 was stated with the following settings: (1) In 2040, higher requirements for an enjoyable eating experience are desired. Science and technology (e.g., sensory simulation technology, holographic image technology,and artificial food technology) are processing rapidly. (2) The eating entertainment industry is intensifying and turning into a trend that motivates people to pursue a variety of sensory stimulation (i.e., taste, vision, and smell) and playful eating experiences. In such background, *Neural technologies for sense augmenting* (n=13), some other *Technology-enabled food modification* (n = 8), and *Services for immersive eating* (n=6) are developed to satisfy people's vivid eating needs in 2040.

Neural Technologies for Sense Augmenting In 2040, eating is not only an experience of taste and smell, but also a multi-sensory experience with hearing, sight, and even touch. By stimulating brain waves or nerves, people can gain a rich and even virtual eating experience in a Metaverse world (Jaynes, Seales, Calvert, Fei, & Griffioen, 2003). For instance, people's consciousness may be linked to the virtual world through wearable technology. In the virtual world, people can consume food that cannot be seen or consumed in the actual world but can be produced by utilizing imagination (P73 and P61). P94 also imagined that "*In 2040, people will no longer take nutrition through food, instead, dreams or hopes will be the source of it.*" However, such pleasure eating experiences may result in addiction issues and slowly evolve into a "*drug*", which influences the normal lives of humans.

Technology-Enabled Food Modification Many products will be diversified and redesigned to provide various flavors and food forms in 2040. For example, "*Spoons enable to change the taste and texture when touching the food, and a pen can draw and change the shape of food in 3D real space.* (P75)" P39 and P54 presented that "*Human imagination is the only element that can limit the eating experience in the future. DIY food is a normal trend in 2040.*" However, such redesigned technologies and products are very expensive, so only rich people can afford them. This might lead to the problem of polarization of wealth in 2040.

Services for Immersive Eating Food entertainment will become a popular service approach in 2040, which focuses on creating pleasant and curious eating experiences. For instance, "*Restaurants use virtual reality technology to provide the experience from preparing, cooking, and ends up in various virtual eating scenes* (P68)." Moreover, "*Chefs begin to develop connections between food flavors and emotions, such as a chili that makes customers experience exciting bungee jumping after eating it* (P88)." However, as people pay more and more attention to sensory eating experiences, the food quality is ignored in 2040.

Scenario 3: Ecology

The *Ecology* scenario imagined by 21 participants presented the background with the following settings: (1) In 2040, environmental pollution and ecological destruction become serious. On much of Earth's surface, it is difficult to cultivate plants and rear animals. Fresh food is therefore expensive and in short supply; (2) Only the wealthy can afford fresh food; everyone else must try hard to survive starving. In 2040, the focus shifts to employing technology to guarantee *Self-growing food* (n=3) and *Recycle food* (n=10) as people struggle to survive with less fresh food. Moreover, people even plan to use *Programmable food* (n=6) as an alternative to filling their hunger. In terms of survival issues and the gap between the wealthy and the poor, manufactured *Black-box food* (n=2) has become an extraordinary method in 2040.

Recycled Food In a world with limited food availability, survival is a fundamental concern for people. Therefore, in 2040, producing food and inventing technological solutions to regenerate more edible food will be crucial. For example, "*Future food production techniques include reviving ruined food and cloning plant and animal cells*. (P17 and P72)" Besides, P96 stated that "*People in 2040 turn attention to daily necessities (e.g., clothes and furniture), attempting to use conversion technologies to make them into edible food*." However, the continuous lack of fresh food has significantly worsened the poor's health. This scenario may potentially produce a distinct socioeconomic class division between the rich and the poor in 2040.

Self-Growing Food To protect and preserve the limited resources of fresh food in 2040, more and more technologies are being developed for food storage. For instance, P16 presented a "*Magic Refrigerator*", in which refrigerators can grow food in a few minutes and preserve food in fresh status forever.

Programmable Food The severe food shortage leads people to explore food alternatives via technical programming in 2040. For example, "*Food++*" is presented by P8, "*By importing food data into a virtual programming software, people in 2040 can design the shape, flavor, and smell of food based on their preferences and printing food out*." Slowly, programming food replaces traditional food, which could reduce the environmental pressure and help to recover the ecological environment on Earth.

Black-Box Food To prevent the robbing of limited fresh food, the government in 2040 order and distribute food (e.g., nutrient bars) uniformly. Thus, people under

management can only survive on the food distributed by the government. In contrast, the managers and the rich can have fresh food and enjoy the food as usual. The problem of social polarization will sharpen in 2040.

6.4.2 Ideation Session

Ideating Design Concepts of Food-Tech Future

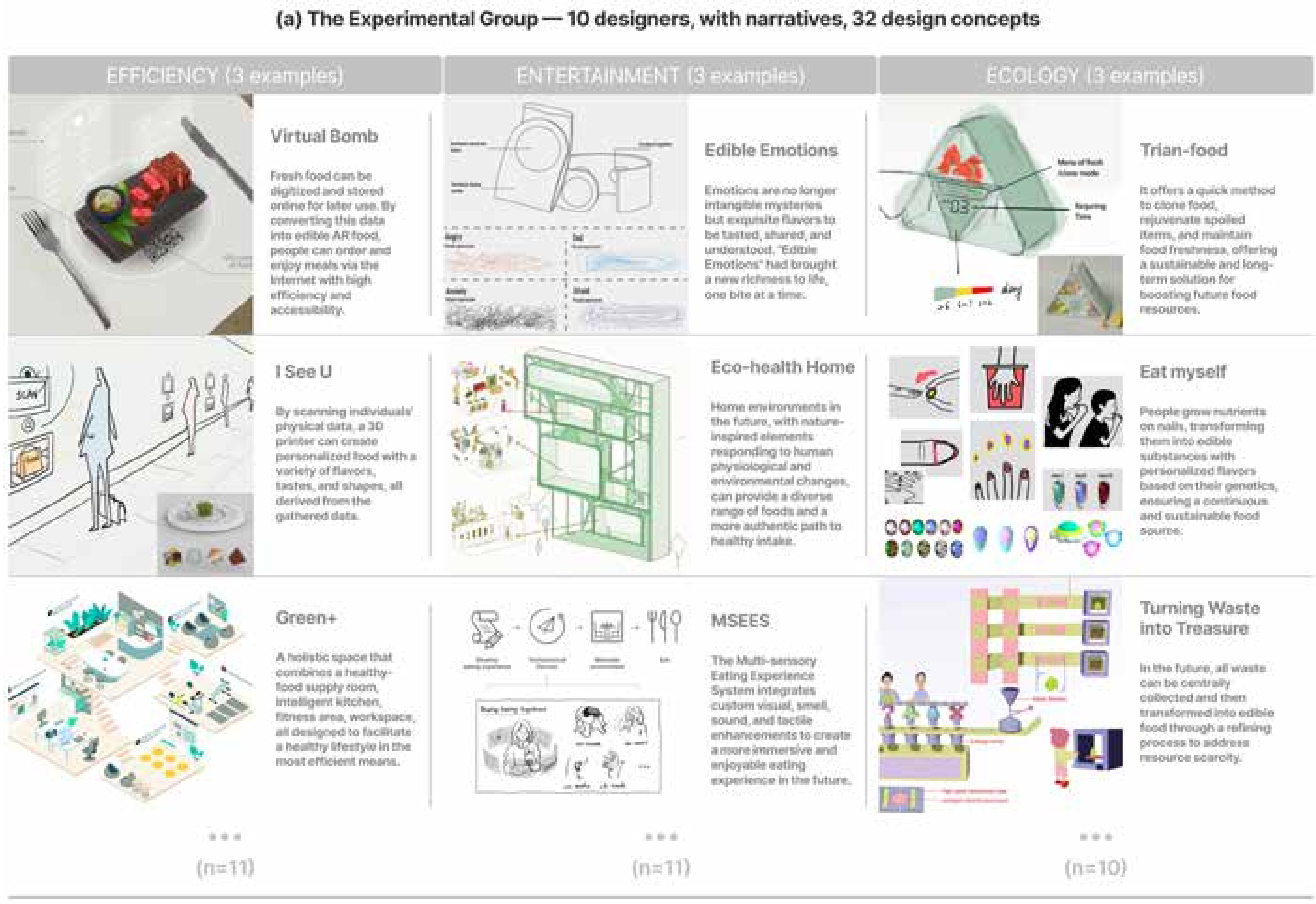
Increasingly, more HFI researchers focus on exploring new ways of transforming eating experiences in the future (Velasco, Obrist, Petit, & Spence, 2018). Meanwhile, some other studies indicated that food-tech futures should not only focus on addressing technological innovations but also on stimulating the core values of food as a means of supplying nutrition, energy, and mental well-being (Comber, Choi, Hoonhout, & O'Hara, 2014; S. Y. Park, Kim, & Leifer, 2017). Our process was guided by the Co-creation approach (Sanders & Stappers, 2008), as it could be useful and effective in envisioning a food-tech future. Based on the three themes (*Efficiency*, *Entertainment*, and *Ecology*) derived from 97 narratives contributed by future users, two groups were formed: an experimental group consisting of ten designers and a control group comprising another ten designers. Giving creative freedom to the designers, these two groups independently developed 32 design concepts and 31 concepts for the food-tech future. Below, we present the 63 design concepts in detail. Exemplar design concepts of both groups can be found in Figure 6.5.

Two groups developed a total of 22 design concepts in the ***Efficiency*** theme. The most popular target group identified by the participants included working individuals (D2, D8, D10, D13, D14, D15, D17, D20), young generation (D1, D3, D4, D5, D9, D19), and common people (D6, D7, D11, D12, D16) in various contexts (such as workplace, home kitchen, supermarket, in the car, and growing farm). One participant (D18) mentioned patients with eating-related diseases in their daily routines. Design purposes and current/anticipated use of technologies were similar between the two groups. For instance, "*Accurate intake of nutritional components*", "*Easy to eat* (such as virtual food, nutrient capsules, edible smoke)", and "*Build up individual ecosystems for healthier food/lifestyle*" were identified as purposes while supporting technologies to achieve them were mentioned as "*3D-printing*", "*Food compression technique*", "*Robotic Assistant*", "*Space shuttle transportation technology*", and "*Data recognition and auto-collection technology for customized eating practices*".

Regarding the ***Entertainment*** theme, a total of 21 concepts were created by both groups. Specifically, children and young adults were identified as essential target groups by many designers in both the experimental group (D2, D5, D8, D10, D15, D18) and the control group (D3, D4, D9, D12, D13, D20), since a playful eating practice enabled them to improve the habit of being a picky eater, relieve negative emotions, and popularize knowledge about healthy eating. Patients (D14) were also explored as important target users since food technologies are potential treatments for diseases (e.g., anorexia nervosa) with creative approaches in the future (e.g., edible chess — eat the pieces that have been lost in a chess game to gain enough neutrinos). Also, family is another motivating factor for enjoyable eating. For example, the singing of family members can be used as data to create food (D1); food technology can emulate the taste of home-cooked meals if family members live remotely (D16); and people can preview the taste and appearance of new recipes to know the outcome before cooking them (D19). In addition, other designers (D6, D7, D11, D17) proposed that common people in the future can stimulate sensory feelings during eating practices via visual, auditory, gustatory, olfactory, and tactile perception of food provided by AR, VR, and other augmented technologies.

In the ***Ecology*** theme, all 20 developed concepts identified human beings as the target group, leading to two main design objectives: ensuring an adequate supply of fresh food and exploring nutrient-rich food alternatives in response to future environmental pollution. Regarding 'adequate supply of fresh food', ten designers across both groups have devised future-oriented solutions, including "*the extraction and conversion of waste into nutritious food* (D4, D7, D8)", "*purification of nuclear wastewater into potable water* (D9)", "f*ood cloning* (D10, D11)", "*food compression technology aimed at reducing volume and extending shelf life* (D15, D19)", and "*the cultivation of plants either through hydroponics* (D17) *or within in-home greenhouses* (D16)". Regarding 'nutrient-rich food alternatives', another ten designers envisioned "*edible insects and processed foods* (D1, D12)", "*growing food from the human body, such as nails* (D2) *and skin* (D3)", "*transforming everyday items into food, e.g., hair/fur* (D5, D20) *and tableware* (D14)", "*lab-grown seafood* (D13)", and "*artificial meat protein* (D6, D18)" were potential choices in the future.

Overall, the experimental group developed 32 design concepts that covered many subthemes outlined in the 97 narrative results from the previous session, such as *Nutrient Concentration*, *Artificial intelligence Robot*, *Virtual intake*, *Services for immersive eating*, and *Self-growing food*. Several concepts were even inspired by a combination of different subthemes from either two or all three themes. In addition to the 97 narratives provided to this group, participants went further with identifying a specific target group, exploring clear design purpose, and developing functional systems and products to show extensions of food-tech possibilities beyond the provided materials. In the control group, there were 31 design concepts, and the outcomes exhibited similarities with the experimental group. Nevertheless, the submissions of 31 concepts to the research team contained relatively fewer details in terms of images and textual content when compared to the experimental group.



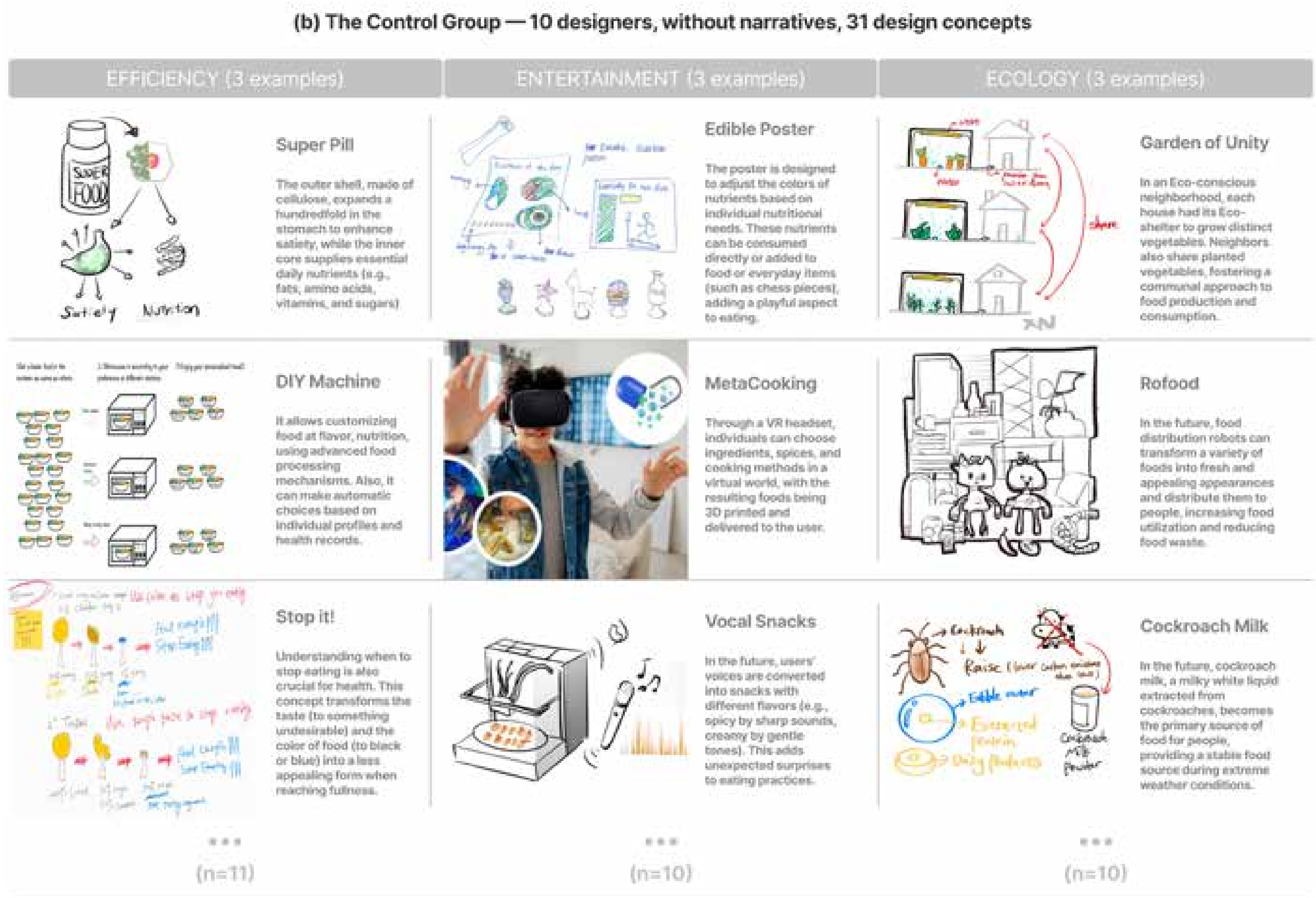


Figure 6.5 Exemplar design concepts for food-tech futures developed by: (a) the experimental group; (b) the control group..

Follow-up Interviews

According to the follow-up interviews after two individual design practices with the experimental group and the control group, most participants showed a positive attitude toward the ideation process. More details of the interview findings are presented as follows.

Introduction of Matrix and Three Themes Both the experimental and control groups emphasized the utility and necessity of introducing the matrix (shown in Figure 6.2) and tree themes (*Efficiency*, *Entertainment*, and *Ecology*) at the outset of the Ideation Session during the process of developing food-tech design concepts. Their reasons were:

> ***A Clarified Structure*** The matrix, featuring two significant drivers (*Eating objective* and *Relationship between humans and technologies*) identified via our scenario planning review, facilitated "*a rapid comprehensive mapping of the food-tech future*". The three themes, identified based on the results of our scenario workshop, ensured "*a clear sense and a well-defined design direction*" for all participants. Besides, the developments of both matrix and themes were considered "*trustworthy*", "*scientific*", and "*supportive*" by most participants.
>
> ***Enhanced Design Efficiency*** Many participants (D1, D3, D4, D5, D6, D7, D12, D15, D17, D19, D20) mentioned that the introduction of matrix and three themes "*provided various background knowledge without requiring additional time and efforts from participants*" and "*helped to locate design opportunities quickly*".
>
> ***Flexible Design Practice for Multifaceted DesignOoutcomes*** Numerous participants stated that a well-defined design direction gave them more space to explore the matrix and themes in alignment with their understanding without restricting their creativity. For instance, D14 mentioned that: "...... *Knowing that I was operating within the scope of the design directions gave me the confidence to explore divergent thinking and creative ideas without hesitation.*" D19 also stated, "*I was surprised by all the design concepts I generated, exceeding my own expectations. I attribute this achievement to the guidance of design directions, which influenced me toward diverse concepts within a remarkably brief timeslot.*"

The Experimental Group vs. The Control Group Participants rated their ideation experiences with an average rating of 8.16 (SD = 2.10) out of a maximum score of 10. Specifically, participants from the control group gave a mean score of their experience as 8.4 (SD = 0.70), which is 1.3 points higher than the experimental group (Mean = 7.1, SD = 2.81). The difference in ratings between the two groups can be attributed to the request for the experimental group to allocate time for reading the 97 printed narratives, a task not required of the control group. Although our research team facilitated the reading process by providing a table featuring the titles and abstracts of all 97 narratives and ensuring all narratives were presented and printed in a well-organized manner, the inherent reading requirement still contributed to variations in the participants' experiences. Also, one participant (D6) felt that the content of the provided narratives could unconsciously draw inspiration, which might influence the final creativity. However, in addition to negative feelings, almost all participants within the experimental group indicated positive experiences with the 97 narratives. Seven participants found that the narratives enabled to serve as a rich source of inspiration for their envisioning of the food-tech future. As some participants mentioned: "*The provided stories have presented me with numerous unexpected design possibilities and insights.* (D2)" "*Some of these stories helped* *me to jump out of my personal design habits and barriers and awakened my creativity.* (D10, D11, D15)" and "*These narratives guided me to expand my focus not only towards product design but also towards the entire industrial service system as well as the speculative thinking on my concepts.* (D5, D6, D18, D19)" In summary, both groups presented a positive experience of the ideation process. An improved approach within the experimental group involved the suggestion of providing narratives "*in digital version*" or "*in advance rather than during the ideation process*" to facilitate more attention on design creativity during the session.

Extra Findings Participants in both groups explained their ideation experiences as "*exciting*", "*interesting*", "*impressive*", and "*creative*". They also gave several primary suggestions for future ideation conduction. First, some participants have proposed extending the duration of the ideation process. They indicated that "*a longer timeslot would afford additional opportunities to refine design concepts with deeper and more speculative thoughts*" and "...... *exploring how these concepts could be effectively translated into practical applications and products within the industry*". Second, due to the text-based nature of the 97 narratives, there existed a shared "*aspiration for the implementation of advanced design tools*" (such as Artificial Intelligence to generate Content tools) to expedite the ideation process and assist the development of design concepts. Third, while the co-creation ideation in our study provided participants with an opportunity to communicate, the potential formation of groups was viewed favorably, as it would enable more in-depth discussions and the development of more detailed concepts compared to working individually.

Evaluating Design Concepts

We have conducted an evaluation to assess the creativity levels of design concepts for both the experimental group and the control group. The three evaluators, two

with a background in design research and one in food design, were provided with 63 design concepts in a random order, including images and text descriptions without any other information. Each evaluator independently participated and utilized the CPSS questionnaire for creativity evaluation by choosing between 18 bipolar pairs of items on a seven-point scale. The total scores from all items were then compiled as the results for each design concept.

Table 6.1 Mean Creativity evaluation results of experimental group and control group by using the CPSS questionnaire.

		Evaluator 1 (SD)	Evaluator 2 (SD)	Evaluator 3 (SD)	Total (SD)
Experimental Group	***Mean***	**56.47 (10.83)**	**69.91 (9.25)**	**64.63 (10.50)**	**63.67 (11.53)**
	Efficiency	50.18 (8.02)	68.91 (9.17)	66.73 (11.98)	61.94 (12.78)
	Entertainment	62.91 (12.89)	72.91 (10.46)	63.09 (10.82)	66.30 (12.05)
	Ecology	56.30 (7.01)	67.70 (7.89)	64.00 (8.98)	62.67 (9.11)
Control Group	***Mean***	**56.16 (14.71)**	**63.42 (12.53)**	**56.94 (12.55)**	**58.84 (13.56)**
	Efficiency	601.8 (18.20)	65.00 (12.28)	53.09 (9.62)	59.42 (14.29)
	Entertainment	54.70 (12.88)	59.60 (13.34)	53.10 (10.56)	55.80 (12.21)
	Ecology	53.20 (12.47)	65.50 (12.39)	65.00 (14.30)	61.23 (13.89)

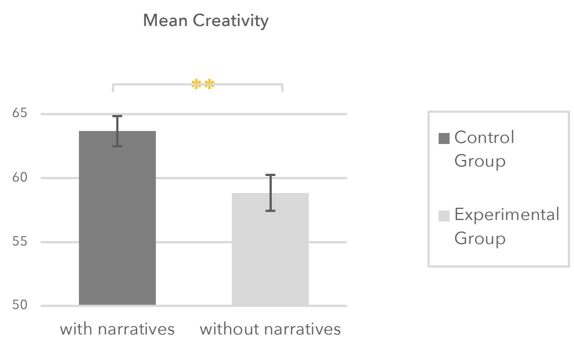


Figure 6.6 Meana and SE of CPSS.

The mean creativity scores were calculated respectively to compare the two groups. The evaluation results are presented in Table 6.1. In general, design concepts in the experimental group achieved a higher mean creativity score of 63.67 (SD = 11.53, SE = 1.18) compared to the concepts in the control group with a mean creativity score of 58.84 (SD = 13.56, SE = 1.41). A Wilcoxon Signed-ranks test indicated a significant difference between the mean scores of the two groups, $p = 0.008$ (shown in Figure 6.6). Additionally, in terms of the scores among the three themes, three evaluators have indicated all the concepts of the experimental group were more creative than the ones in the control group, except the *Efficiency* theme scored by E1 (shown in Table 1). The reasons behind this difference were explained by E1 as "*I thought that this theme focuses on problem-solving-oriented concepts to ensure quality intake in the future...... and my personal daily eating experiences and requirements significantly impact my scores in a big way.*" However, according to three evaluators, the experimental group have scored 56.47 (E1), 69.91 (E2), and 64.63 (E3), while the control group assessed overall lower ratings with scores of 56.16 (E1), 63.42 (E2), and 58.84 (E3). The creativity evaluation results have revealed that design concepts inspired by narratives from future users were generally more

creative than those developed without inspirational materials. The collaboration between future users and designers could improve the creativity of design concepts for food-tech futures.

6.5 Discussion

This chapter aims to investigate how to engage future users and designers in a collaborative ideation process for food-tech futures. We proposed and developed a participatory approach called the Collaborative Ideation Approach, which was identified as an efficient means to answer our research question. We found that future users' scenario narratives could engage designers in developing more creative concepts for food-tech futures, facilitating a dynamic dialogue between future users and designers. This approach also stimulated the exploration of presuppositions and ramifications related to the topic of future eating and food-tech future, as indicated by the findings of our study. Below, we discuss our main contributions regarding opportunities and tensions of the Collaborative Ideation Approach, discussion of design concepts regarding three themes, as well as limitations and future works.

6.5.1 Opportunity and Tension of Scenario Co-creation

The Collaborative Ideation Approach was introduced as a participatory design practice for early and formative design concepts in this chapter.

First, as shown in Figure 6.7 (a), one opportunity of the Collaborative Ideation Approach is the potential integration of the Explorative Scenario Planning (Planning For Hazards, n.d.) as a valuable method at the early explorative stage.

This approach could be employed to produce a large number of fictions and ideas with multiple future scenarios. Thus, it could serve as an orienting framework to provide themes or directions for further imagination and design.

Second, as shown in Figure 6.7 (b), one key tension of the Collaborative Ideation Approach relates to drawing future users into a space of creative spark. Individuals with no design background may shy away from creating future imaginings that demand unfamiliar skills such as sketching (Blythe et al., 2018). Thus, the research team contributed to bringing in prompts and facilitated a discussion during the workshop about what future scenarios were to be developed and written about, while participants brought in their writing experience together with their actual life experiences, beliefs, and practices. The evidence shows that using the Scenario method as a stimulus in the workshop could help future users reflect on present technological developments and transformations into future lives (both individual and social) they will face by themselves (Rapp, 2020). It was also found in some prior studies that inspiring activities like storytelling were recommended during the early phase of design, aiming at eliciting heuristic perspectives into specific design topics (Deng et al., 2021; Verhoeven, 2023) and grounding users' ideas for efficient design practical procedures (Buskermolen & Terken, 2012).

Thirdly, another opportunity for the Collaborative Ideation Approach is the transition from text-based narratives to visualized design concepts. Based on personal eating experiences, individuals from non-design backgrounds could have a chance to speak out their understandings and perspectives of the future via storytelling. Designers found such storytelling cues were useful and usable, as they played as specific sources of inspiration for the visualization of concepts for future food and technologies directly. Furthermore, our research also demonstrates that a multidisciplinary creative collaboration between future users and designer was successful in capturing a nuanced and creative perspective on the food-tech future (Figure 6.7 (c)). It enabled to approach future HFI from a new perspective of envisioning eating scenarios, and then could be valuable to derive insights and provoke discussions within a co-creation process (Dolejšová et al., 2020). Similar to other studies (Dindler & Iversen, 2007; Farias et al., 2022; Talgorn, Hendriks, Geurts, & Bakker, 2022) that highlight the importance of a collaborative design process of future exploration with a variety of participants, our research revealed that the quality of future narratives produced by future users is good enough to effectively inspire designers to come up with futuristic concepts and food-tech innovations, as well as to produce design modeling and illustrated concepts.

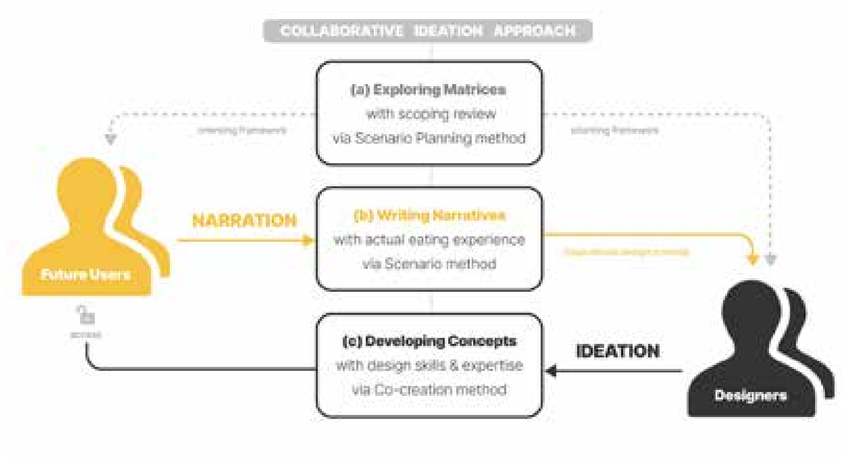


Figure 6.7 The protocol of the Collaborative Ideation Approach.

In summary, we recommend adopting the Collaborative Ideation Approach in relevant practices, as it empowers multiple stakeholders to articulate their future visions and develop creative design outcomes. Additionally, this participatory approach might also be used in research with a specific topic (e.g., healthy eating at work, food-related robotics, and virtual eating) to explore design possibilities in future food-tech investigations.

6.5.2 Discussion of Design Concepts for Food-Tech Futures

In contemporary HFI research, there is a growing interest in exploring innovative methods to enhance eating experiences through the integration of emerging technologies (Velasco et al., 2018). In the two sessions we conducted based on the Collaborative Ideation Approach, 97 future narratives were created and then used to co-create future food-tech concepts within three main themes, namely *Efficiency*, *Entertainment*, and *Ecology*. As a result, a total of 63 design concepts were developed. Thirty-two design concepts inspired by 97 narratives were proposed by 10 designers, while another 10 explored 31 creative concepts without any narrative influence. Through the analysis of narrative outcomes and design concepts, the envisioned food-tech futures held promising potential for realization. This potential was particularly notable in light of recent HFI research, which has highlighted several food-tech implementations, including:

Robotics Recent HFI studies supported that a food mechanism to manufacture nutrient-balanced food based on one's physical data could be implemented in the future. Both 'personal service robotics' with the fastest growth rate over the coming decades (Thrun, 2004) and 'food printing technology for individualized foods' (Yang, Zhang, & Bhandari, 2017) can offer a viable basis for personalized future eating experiences.

Virtual Food Emerging studies showed possibilities of AR technology and digital food to alter food's visual qualities (i.e., texture and color) (Nishizawa, Jiang, & Okajima, 2016), display full-size 3D representations of food in a restaurant ("HoloLamp," n.d.), and develop a 2D-3D hydration process to speed up delivery process (Wang et al., 2017), but creating edible AR and digital food with evidence-based and well-integrated scale would take time and a fundamentally interdisciplinary approach. The good news is that research has begun to make a stronger effort to turn fictional concepts into reality. One significant example is 'Digital Gastronomy' (Zoran & Coelho, 2011).

Multisensory Eating Experience With augmentation technologies, future eating enables to be changed (Spence & Piqueras-Fiszman, 2013) regarding the 'food visual characteristics' (e.g., texture (Okajima & Spence, 2011), color modified by AR (Narumi, 2016; Nishizawa et al., 2016) and VR (Bruijnes, Huisman, & Heylen, 2016)), the 'sounds' (e.g., chewing sound (Zampini & Spence, 2004), environmental noise (Woods et al., 2011; Yan & Dando, 2015), music (Crisinel et al., 2012), eating sound interval (Kadomura, Nakamori, Tsukada, & Siio, 2011), and interactive sounds with food (Kadomura, Tsukada, & Siio, 2013)), and 'tactile interfaces' (e.g., for the lips (Tsutsui, Hirota, Nojima, & Ikei, 2016), for biting (Iwata, Yano, Uemura, & Moriya, 2004), and for cutlery and tableware (Hirose et al., 2015; Spence, 2017)). HFI researchers, who emulate real-life eating experiences, stated that developing dietary technologies associated with different sensory augments would have a high expected growth rate and provide a potential foundation for high-level eating experiences in the future (Kita & Rekimoto, 2013).

3D-Printing Technology Several advanced food-tech innovations (i.e., 3D printing and 4D printing) have emerged as potential tools for synthesizing novel flavors and food structures to provide high-quality and delectable future eating practices. For instance, one advantage of 3D printing food (Yang et al., 2017) is the ability to customize and freely modify the ingredients, tastes, forms, and textures to suit the health conditions, lifestyles, and appetites of various individuals. However, due to the slow pace of 3D printing technological development, certain existing techniques are only sporadically employed in the medical industry (for example, 3D printing for oral medication administration (Pandey et al., 2020; Vithani et al., 2019)). Nevertheless, this implicated direction is a potential design space for the HFI research field.

Food Alternatives Ecological change is predicted to lower global agricultural yield (Nelson et al., 2010; Rosenzweig et al., 2014) and impacts population health by changing dietary composition (Springmann et al., 2016). Additionally, due to deforestation, world meat production already accounts for 15% to 24% of all greenhouse gas emissions. If we continue to optimize the use of agricultural resources, meeting future meat demand would be difficult (Steinfeld et al., 2006). Recently, the development of meat alternatives has been increasing (Moritz, Verbruggen, & Post, 2015). Such alternatives like in-vitro-meat and myocyte culturing may possibly alleviate the ecological burden and determine meat production better by demand (Datar & Betti, 2010; Hocquette, 2016). Therefore, we hope the design concepts proposed in our study will be a potential direction to solve the agricultural problem raised by the ecological environment in the future.

6.5.3 Limitation and Future Work

Due to the following limitations, the research findings may need to be carefully interpreted. First, the Scenario method and Co-creation method encouraged open-mindedness, magnified social/environmental issues, and was unconstrained by technological advancements. Therefore, rather than being intended as practical advice, the design concepts of food-tech futures were established as a possible reference and emerging paths for future eating. Second, the study did not consider more specific demographic varieties of the participant group, such as the sex ratio. And the results that emerged from the Chinese urban context were not generalizable to other cultural contexts. Third, we did not investigate specific topics for future eating; instead, the matrix for future eating based on scenario planning (Figure 6.2) played as the foundation in both the *Explorative Scenario Session* and the *Ideation Session*. For further work, it might be worthwhile to investigate a topic-based creative workshop to expand the research base and design orientations in further studies. Some other design tools, such as AI-Generated Content tools, could be involved in the ideation process to improve the efficiency and quality of results. Moreover, the design outcome might benefit if we share the findings and eating scenario proposals with HFI researchers and experts. Their advice would be valuable in helping us modify and enhance our design concepts for food-tech futures.

6.6 Conclusion

This chapter presents a Collaborative Ideation Approach to engage future users and designers in developing future eating scenarios and food-tech design concepts in 2040. An *Explorative Scenario Session* and an *Ideation Session* were conducted. In the *Explorative Session*, our research team identified a matrix for food-tech futures through a scenario planning review and recruited 116 participants to create narratives of future eating using the Scenarios method during the workshop. In total, 97 selected narratives were categorized by thematic analysis into three themes: *Efficiency*, *Entertainment*, and *Ecology*, serving as the foundation for the Ideation Session. In the second *Ideation Session*, one group with ten designers explored 32 design concepts inspired by the 97 narratives, while another control group with ten designers proposed 31 concepts without narratives. A total of 63 design concepts were evaluated via the Creative Product Semantic Scale by three design-background evaluators. Our findings demonstrated that narratives from future users can improve the creativity of design concepts for food-tech futures generated by designers.

Our approach has shown the value of engaging future users in envisioning future eating. Their thoughts, desires, and fears can be taken by professional designers for exploring design concepts of food-tech futures. Considering that individuals without design expertise are the potential users of HFI technologies today, we hope our findings of the Collaborative Ideation Approach and design concepts could inspire HFI researchers and designers to focus more on creating interdisciplinary integration between future users and designers for exploring innovation around eating experiences and food-tech futures. Additionally, we recommended that future studies with specific design topics continue to adopt this participatory approach to explore HFI food technologies and design opportunities in a co-creative way.

PART IV | REFLECTING

In this dissertation, we have explored (1) various studies to understand healthy eating practices and routines in the working context, (2) playful self-reported tools for working-age individuals, and (3) a collaborative ideation approach for future design regarding food technologies. In this part, we bring together insights from all previous parts to present our conclusion and design implications.

In Chapter 7, we draw our research to a conclusion by revisiting the initial research questions posed at the start of this thesis. Following, we present the limitations of our studies and explore how our findings can be extended and applied in future research aimed at promoting healthy eating among working-age individuals within the working context during working hours. Additionally, as a way to generalize our findings, we also proposed six design implications and four practical challenges in Chapter 8. With these considerations, we hope to inspire further research and design in this area.

7 Conlusion

7.1 Answering the Research Questions

The research in this thesis was primarily motivated by the need to make people aware of the importance of healthy eating practices in the working context. Unhealthy eating at work increases the risks of various non-communicable diseases (such as obesity, cardiovascular diseases, and type II diabetes) and threatens individuals' physical and psychological well-being (Afshin et al., 2019; Gakidou et al., 2017; World Health Organization, 2014). Promoting healthy eating activities in the working context is suggested by the literature as the key to improving quality of life and can offer design opportunities to live well among working-age individuals. For decades, the rapid advance of health-promoting technologies (i.e., mobile applications, digital interventions, and wearables) has great potential to increase the effectiveness of healthy-eating promotion at the workplace. Furthermore, implementing interactive approaches for healthy eating has become one of the major objectives of public health, which leads to an emerging field to gain mainstream attention from researchers working with occupational eating stimulation. Therefore, in this thesis, we formulated the following research question:

> ***How to design digital tools to promote healthy eating in the working context?***

We briefly summarize the findings emerging from underlying studies to offer some insights into this initial research question. Before we discuss the design opportunities and implications of this thesis, in what follows, we present our conclusions on our four specified research questions based on the findings from the corresponding chapters.

7.1.1 Answer to RQ 1 throughout Scoping Review (Chapter 2)

> ***RQ1:*** *What is the state of the art of digital tools and interventions to promote healthy eating behavior in the working context?*

To zoom our focus on developing emerging technological tools for promoting healthy eating in the working context, we carried out scoping review research. We provided insight into state-of-the-art technologies and interventions to reduce unhealthy eating behavior or to stimulate healthy eating routines and patterns at work. In total, sixteen papers were included and analyzed on study characteristics, objectives, theoretical underpinnings, design approaches, as well as types of technology and design. The included papers were published in conference proceedings and journals between 2010 and June 2021.

Our review's two most common objectives were detecting daily eating moments and encouraging healthy food choices. The review paper showed that mobile applications and wearables were normally used to detect eating-related data, such as intake content, eating moments, eating frequency, and eating duration. We found limited evidence for the integration of technology tools into dynamic eating-work routines, work contexts, and occupational infrastructures to increase user engagement. Moreover, based on the findings of our scoping review, we suggested that future design research could (1) investigate interactive and playful digital tools with user-centered approach and behavior change techniques (e.g., rewards, persuasion, and self-reflection) to promote healthy eating behaviors and routines during working hours; and (2) involve intake measurements into occupational healthy eating promotion, and more technologies and designs could be evaluated to show the effectiveness of outcomes.

In line with this, we discovered that it was difficult to effectively encourage working-age individuals to eat healthier at work due to insufficient comprehension of the contemporary working context and a lack of playful ways. These challenges provide insights for further investigations into understanding the working context and exploring playful dietary self-reported tools in health promotion. These insights led to the second research question of this dissertation.

7.1.2 Answer to RQ 2 throughout Contextual Exploration (Chapter 3)

> ***RQ2:*** *What contextual factors should be considered when designing interactive features to promote healthy eating in the working context?*

To understand the working context and explore design implications for healthy eating promotions, we conducted contextual explorations in a real working environment in the Netherlands. The empirical explorations are two-fold. On the one hand, a user-centered contextual inquiry study involving an online questionnaire and a semi-structured interview was conducted to identify design opportunities for digital tools to enhance individuals' eating routines during working hours and find strategies to apply digital health to the working context. The results concluded four considerations that lead to current eating patterns (i.e., *Well-being*, *Productivity*, *Health*, and *Energy support*), four aspired features of digital tools to improve eating patterns at work (i.e., *Support accessing relevant knowledge*, *Enable planning and goal setting*, *Combined with health programs*, and *Facilitate social supports*), as well as two recommended strategies (i.e., *Integrating health-promoting digital applications into the working context* and *Providing system feedback according to individual differences*).

On the other hand, to practice the design opportunities of promoting healthy eating in the working context, we generated four design concepts found in the prior inquiry study into a mHealth application called EAT@WORK, containing UX features of *Knowledge for me*, *Goal assistant*, *Health program*, and *Social support*.

To test the usability and applicability of EAT@WORK, a formative user study (N = 14) was set out using a within-subject experiment and an online co-creation session. We learned from the results that EAT@WORK was an easy-to-use and useful digital tool in facilitating healthy eating for working-age individuals due to its integrations among various eating-related elements (e.g., eating-related knowledge, physical health program, and social support), as well as its user-friendly and well-designed interfaces. Moreover, the results from the co-creation session interviews indicated that planning eating routines and achieving eating goals in the working context played the most useful feature, while physical health programs and social support have impact on eating behavior but are not the main effect. The valid knowledge of eating was considered an on-demand feature by most participants.

Based on the findings of ***RQ2***, we explored our understanding of contextual factors for eating practice at work. The results of the two exploratory studies provide insights into the design for healthy eating promotions by involving contextual factors and implementing digital tools based on working routines as well as workday context. Additionally, with the growing interest in mHealth tools for health promotion at work, we found the potential of customized user experiences and feedback as a promising way to sustain individuals' motivation in stimulating healthy eating activity while working. Following these insights, we suggest that health-oriented digital tools should adapt to real-life working contexts and individuals' daily routines, which leads us to the *RQ3*.

7.1.3 Answer to RQ 3 (Chapter 4 and 5)

> ***RQ3:*** *In a real-life working context, what self-reported dietary assessment method is an effective tool and how can it be explored with a playful approach?*

Based on the previously outlined findings, we continue the exploration of the third research question. Due to the COVID-19 pandemic, the workplace has rapidly shifted from office to work-from-home (WfH). Thus, to address this third research question, we explored the research field in the WfH context with two studies through a combined research phase (Chapter 4) and design phase (Chapter 5) based on two research tools, namely the Traqq app and NutriColoring toolkit.

The first study was a within-subject study with the Traqq app (N = 30) focusing on the practice of mobile self-reported dietary assessment approaches during working hours (Chapter 4). Two self-reported approaches (4-hour Recall method vs. Food Record method) were compared over a 4-week period. Our quantitative results revealed that working-age individuals presented high acceptance of the Food Record method during their working hours at home because of a more flexible completion time and lower mental burden. Besides, possible motivations for individuals to report food intake in the WfH context were integrating reminders of digital tools into workday routines, simplifying the self-tracking process, and adding gaming/playful elements into the digital tools.

In response to the findings learned in Chapter 4, we developed the second study (Chapter 5) with the design and field test of the NutriColoring toolkit, a paper-based reporting tool via Coloring approach that aims to prompt self-tracking and self-reflection about daily intake in the working context. Specifically, the NutriColoring toolkit was designed with two features: (1) We integrated the Food pyramid into the NutriColoring toolkit and appropriated food categories with six corresponding colors: Orange (Grains), Green (Vegetables), Yellow (Fruits), Red (Fats, Oils and sweets), Blue (Milk and Dairy), and Pink (Meat); (2) 30 line-drawing cards with various meal contents were developed to facilitate color-it-up reporting approach in the working context. A cultural probe study (N = 18) showed coloring as a positive approach could be used as a playful form of self-reporting for health promotion at work. The use of the NutriColoring toolkit was perceived as entertaining and convenient and stimulated reflection on one's food intake during working hours. Furthermore, the findings suggested that a simple and unobtrusive reporting method, social support, and artistic user intake profiles can help deliver tailored feedback that considers contextual and personal health factors.

7.1.4 Answer to RQ 4 (Chapter 6)

> ***RQ4:*** *How to envision future roles of innovative food technologies in facilitating healthy eating through a collaborative design approach?*

Our fourth research question is addressed through a research project (Chapter 6) with three steps to explore a holistic viewpoint of the food-tech future with new eating practices and technologies in 2040. A Collaborative Ideation Approach with three steps was conducted, including an initial scenario-planning review, a creation workshop based on the Scenario method with 116 potential users for collecting imaginary narratives, and a co-ideation session for composing design concepts for food-tech futures. As a result, we constructed a framework for future-eating imaginations, which was used by 116 future users to come up with three hypothetical future eating scenarios: *Efficiency* (strict dietary regulation), *Entertainment* (increasing virtual experiences), and *Ecology* (looking for food alternatives). Moreover, 97 stories were eventually included in the analysis process. Ten designers were inspired by 97 narratives to compose 32 design concepts, while another ten designers developed 31 design concepts without inspiration. All 63 design concepts were evaluated by three design-background experts in design research and food design domain. Our findings demonstrated that narratives from future users can improve the creativity of design concepts for food-tech futures generated by designers.

In relation to our prior explorative studies, we looked ahead to the future with a Collaborative Ideation Approach, combining the scenario planning, the scenario method workshop, and the co-ideation method. This approach aimed to allow potential future users an opportunity to express possible scenarios and imaginings about future food technology based on their daily eating experience, knowledge, and skills, which could serve as beneficial inspirations to designers to develop Human-Food Interaction design concepts. It also made it possible to create structured proposals for future food technologies for a successful enhanced design aspect of health promotion.

7.2 Limitations and Future Work

Our research presented in this thesis has limitations. In addition to the limitations of the various studies discussed in the previous chapters, here we briefly address the more general limitations applicable to this dissertation.

First, the studies conducted in this thesis were exploratory and were not designed to evaluate effect sizes regarding healthy eating behaviors and routines. The exploratory character of this dissertation resulted in the inclusion of several studies using a research-through-design approach. These studies served an important purpose: while some provided preliminary findings of health-eating promotions, others presented thought-provoking implications and new design insights for future research. These studies aimed to help broaden the research scope and increase collaboration with researchers from HCI and other various fields.

Second, the environment in which our studies were conducted holds limitations. Our research presented in Chapter 3, 4, and 5 were conducted in a specific working context (i.e., desk-computer-based working setting in the Netherlands)

over relatively short periods, which might not be adequate to prove the effectiveness of our designs on promoting healthy eating for a prolonged period. Additionally, we need to cautiously interpret implications derived from our studies when applying our findings to broader and diverse working circumstances. Therefore, it is necessary to conduct long-term studies with working-age individuals from a variety of occupations in the future. Also, we anticipate conducting further replications of research studies in other working settings and environments to assess the generalizability of our findings and determine whether the same explorations and effects persist. On the other hand, due to the COVID-19 pandemic, work-from-home will be a "new normal" work situation. Although we did focus on exploring the design opportunities for both home office venue and traditional office venue, it shows a question of which insights can be transferred to the home office context and keep the dynamic between the two working venues. Thus, more research should be developed to answer this question and think about how we can adapt to the new future reality.

Third, in this thesis, we focus on exploring and designing interactive tools and technologies to facilitate healthy eating behaviors and promote eat-work dynamics in the working context. However, the effectiveness of these tools and technologies as daily objects for improving working vitality has not yet been investigated. In the future, it might be interesting to conduct studies using our prototypes and tools in the real world, instead of using them only as research tools for lab-based experiments. Besides, according to findings (in Chapter 2) and user feedback (in Chapters 3 and 4), the **lack of customization and personalization of digital tools for individuals within a working context** is another limitation. In this thesis, we offered experiences expected to benefit most working-age individuals instead of tailoring them according to personal diversity. Future designs and work should keep exploring personalized features within the technologies and tools for healthy eating since personalized approaches and solutions relating to personal experiences, characters, and needs can significantly benefit individual users.

Another limitation regards the **potential influences of gender, working status, and other personal characteristics of participants, which has not yet been further investigated due to an insufficient sample size**. Thus, future studies should consider recruiting a sufficient sample of individuals from various working contexts or with other characteristics for a deeper understanding of how designs and personal attributes can shape health-promoting technologies. Also, future work could gather more evidence for guiding gender-specific designs in exploring healthy eating interventions for gender differences. On the other hand, as emphasized in Chapter 6, we look beyond what has been presented so far, envisioning what to provide as useful tools for healthy eating at work and how to design rich technologies and interactions for vivid eating experiences in the future. However, we conducted an **envisioning study limited to future food technologies with a single stakeholder** — the young generation. The choice was intentional because young adults are the potential working group in the future and are not influenced by existing working experience when imagining the future from a wide-range perspective. Additionally, we propose that further investigations should involve the potential young generation or occupied individuals in the exploration and design process in the future.

8 Implications

8.1 Introduction

This chapter presents implications learned from this research journey to help inform future research and design processes. Although our research in this thesis is mainly exploratory, it still provides several insights to design for occupational health promotion. Specifically (shown as follows), we proposed six design implications targeting the primary research objective of this thesis — designing digital tools to promote healthy eating among working-age individuals in the working context. Also, we suggested a number of practical impliactions closely related to design and research challenges with and for our working-age user group when conducting design research for healthy eating promotion. However, these derived implications are limited to the specific scope and context of our research. We hope designers and researchers working in the relevant research field could be inspired to discuss as well as extend research focuses based on our implications and then transfer these findings and implications into future design processes and practices.

Proposed Design Implications:

- Design Implications 1 (based on Chapter 2, 3, and 5):
  Leverage Behavior Change Intervention

- Design Implications 2 (based on Chapter 2, 3, 4, and 5):
  Explore Routine-Based Interventions

- Design Implications 3 (based on Chapter 3):
  Weave the Rhythm between Eating and Physical Activity

- Design Implications 4 (based on Chapter 3):
  Support Social Value of Design

- Design Implications 5 (based on Chapter 2, 3, 4, and 5):
  Incorporate Playful Features

- Design Implications 6 (based on Chapter 2 and 6):
  Expand Possibilities of Multisensory Experience

Proposed Practical Implications for Challenges:

- The First Challenge regarding the Change in **Working Context**
- The Second Challenge regarding the **Target Users**
- The Third Challenge regarding the **Consistent Language within Multidisciplinary Fields** for Healthy Eating Promotion
- The Fourth Challenge regarding the **Collaborative Ideation between Users and Designers** for Developing Concepts for Food Technologies

8.2 Proposed Design Implications

First, the design gaps and opportunities found in Chapters 2, 3, and 5 are the basis of Implication 1, which aims to encourage behavioral change processes to reduce unhealthy eating situations at work. This implication is in accordance with the guidance of the behavior change approaches, for instance, the Transtheoretical Model (Velicer, Prochaska, Fava, Norman, & Redding, 1998), the Theory of Planned Behavior (Ajzen, 1991), Goal Setting Theory (Locke & Latham, 2002).

Second, the findings in Chapter 3 suggested Implication number 2, which claimed that promoting healthy eating should be able to integrate into working routines and settings without obtrusive context alteration. Also, using existing workplace infrastructure, tools, or systems was considered a means to make the adoption of dietary technologies and interventions in the working context easier.

Third, promoting healthy eating at work should not be limited to seeing eating activity alone in the working context. Based on the findings of Chapter 3, we formulated Implication 3. Consuming nutrition-balanced foods, along with getting regular physical exercise, enables individuals to reach and sustain healthy vitality.

Fourth, Chapter 4 revealed that it is important to provide social support to stimulate healthy eating practices in the working context. As a result, Implication 4 highlighted the need for peer support (e.g., colleagues and friends in the office context or family members in the work-from-home context) to adhere to healthier eating behavior during working hours.

Fifth, based on the findings of the Scoping review (Chapter 2) and user studies (Chapter 3, 4, and 5), Implication 5 was proposed. This implication attempts to introduce playful features into interactive technologies and tools for promoting healthy eating. It could render such dietary technology and other associated tools more acceptable and enhance an individual's willingness to utilize them during regular working hours.

The final implication, proposed in accordance with Chapter 6, should be viewed as a feasible hypothesis rather than a proven insight. The design of future dietary tools should offer multisensory experiences as meaningful activities to improve the using engagement within the specific working context.

These six implications aim to provide design opportunities for yet-to-be-explored interaction design and tools to stimulate healthy eating practices in the working context. More details about these implications are mentioned as follows.

Design Implication 1: Leverage Behavior Change Intervention

Regarding the first identified approach, it is proposed by a multitude of practices and theories that guide the behavioral change process needed in the global challenge to reduce unhealthy eating status. Throughout our research, we found a group of behavior change techniques was expected in healthy eating promotion, for instance, *Goal setting and planning*, *Feedback and monitoring* (e.g., Self-monitoring of behavior), *Social support*, *Shaping knowledge* (e.g., instruction on healthy eating performance or behavior), *Comparison of healthy eating behavior and intake data* (e.g., social comparison with eating partners), *Reward*, and so on. Here, we suggest further research on healthy eating promotion at work could ground in the Behavior Change Wheel. **Behavior Change Wheel** (Michie, Van Stralen, & West, 2011) is developed by Michie et al., which provides a three-layers systematic guide for designing behavior change interventions in the healthy eating research domain. Specifically, Capability, Opportunity, and Motivation are three circular layers, surrounded by nine intervention functions (i.e., education, persuasion, incentivization, coercion, training, enablement, modeling, environmental restructuring, and restrictions) as the second layer. The third layer and outer rim of the entire wheel are seven policy categories (namely environmental/social planning, communication/marketing, legislation, service provision, regulation, rascal measures, and guidelines) supporting intervention design delivery. In addition, a well-designed behavior change intervention should modify at least one core element of the circular layers of the wheel and use the second and third layers to direct the behavior change process. On the other hand, the **Intervention Mapping protocol** (Bartholomew, Parcel, & Kok, 1998) (a practical model for creating effective behavior

change interventions with an iterative path of six steps from problem identification to evaluation planning) and the **Transtheoretical Model** (Velicer et al., 1998) (stimulate the decision-making process to act on a new healthier behavior with six stages of change, namely pre-contemplation, contemplation, preparation, action, maintenance, and termination). In addition, we believe that integrating the Behavior Change Wheel and related applied models into healthy eating interventions could be a potential and helpful approach to stimulate healthy eating practice in the working context. Based on the second layer of the behavior change wheel (intervention functions), we propose possible implications to make the unhealthy eating behavior change happen:

Education: Increasing individuals' knowledge about the importance of a healthy diet.

Persuasion: Inducing positive feelings and awareness of healthy food choices and eating routines.

Training: Providing training opportunities to improve working-age individuals' skills in purchasing healthy food, cooking with healthy ingredients, and developing habits of regular eating rhythm.

Modeling: Building examples of healthy eating routines and practices for working-age individuals to aspire to or imitate when they process their eating activities at work.

Coercion: Increasing the cost of unhealthy snacks and food in the workplace.

Restriction: Using office rules to reduce purchasing or easy access to unhealthy food in the canteen, supermarket, or vending machines.

> **Environmental Restructuring:** Using prompts in shops in the working context to increase the attractiveness of healthy food, such as fruits and vegetables.
>
> **Enablement:** Providing behavior support, for instance, merging eating activity with working breaks, keeping the balance between intake quality and workout during working hours.
>
> **Incentivization:** Creating an expectation of rewards if one achieves short-term challenges or consumes fruits and vegetables daily.

Moreover, we also suggest leveraging a combined use of theories related to behavior change to facilitate improved self-efficacy and healthy eating intention in the working context. For instance, according to the **Goal Setting Theory** (Locke & Latham, 2002), an activity goal with a suitable level of skepticism and difficulty might result in strong behavioral commitment. Also, supporting goal-setting and facilitating goal-achieving activities could be a useful approach to shaping positive attitudes toward healthy eating practices (West et al., 2017). Besides, the **Theory of Planned Behavior** (Ajzen, 1991) could serve as a powerful tool to identify motivational attitudes toward healthy eating, subjective norms in the working context, and perceived ease or difficulty of performing healthy eating behavior results. In this proposed implication, it is essential to change the perceived ease of behaving with healthy eating patterns as well as routines at work and restructure the working environment to make healthy food or/and behavior a more visible part of the working practice. We believe that by doing so, it would be useful to help working-age individuals develop self-awareness and self-reflection on healthy eating, especially in the working context.

Design Implication 2: Explore Routine-Based Interventions

Implication 2 emphasizes motivating healthy eating at work by integrating the format of dietary technology and intervention into personal daily routines to increase user engagement. In a daily working context, individuals have a scheduled working plan and a structured eating practice. Although creating regular daily routines (e.g., eating at the same time every day and making solid working routines) (Sandra Lopez-Leon et al., 2020) is essential for health promotion at work, eating practices were easily influenced by individuals' working schedules and routines. One potential solution to this issue could be helping people maintain a regular routine to balance the tension between working and eating in their real-life context (Spahn et al., 2010; West et al., 2017). Furthermore, we propose four explicit design opportunities in response:

> First, one opportunity could be a platform that connects to working-age individuals' working schedules for planning proper eating time during working hours.
>
> Second, to increase the adoption of technological interventions for office eating routines, a more personalized service system could be a design opportunity. For instance, the digital system behaves like a personal health specialist that enables one to learn an individual's daily routine over time and provide personalized suggestions according to the individual's health- and work-related status.
>
> Third, setting reminders might help build healthy eating actions into a habit after weeks of routine (Lally et al., 2010). By having regular routines, working-age individuals could decrease the risk of having mental or metabolic disorders (Maes et al., 2012) and gain long-term health practice.

Fourth, using existing objects and infrastructures in the workplace to reduce additional time requirements of working-age individuals to establish healthier eating routines during working hours.

Design Implication 3: Weave the Rhythm between Eating and Physical Activity

The third implication addresses the rhythm of eating and physical activities in the working context. Eating a balanced diet and being physically active are two key lifestyle factors for sustainable health, which are also strongly linked to each other. Consuming a balanced diet includes eating proper portions of nutrients to maintain a healthy weight and nourish the personal body while physically active regarding types and amounts of physical activity that are linked to health benefits. However, since intake restriction lowers basal metabolic rate, physical exercise should be added to workplace health promotion to overcome the negative effects of eating patterns. Thus, we proposed that researchers in the health promotion field should tackle high energy intake and support active physical exercise to reduce eating-oriented risks, such as type 2 diabetes and obesity. In addition, eating and physical activities occur in various contexts and sites during working hours (for instance, office, canteen, café, and meeting room). A potential endeavor to stimulate healthy eating behaviors with physical activity at work could be combined technologies and interventions in multiple environments (i.e., office, canteen, or meeting room) and focus on individuals' personal abilities instead of organized office programs.

Design Implication 4: Enable Peer Support

The fourth implication is implementing a peer support approach to sustain

individuals' interests and boost their engagement while using dietary technologies for healthy eating promotion. Normally, working-age individuals prefer to eat together with other people (e.g., colleagues and co-workers) in their daily working environment. The reciprocal relationship that occurs through the sharing of eating experiences may benefit health promotion (Dennis, 2003; Funnell, 2010; Michele Heisler MD, 2007), such as gaining new personal eating-related knowledge and receiving social approval from the person they eat with. Also, peer support (could be known as the individuals who have similar eating routines, eating goals, and personal characteristics in the working context) enables exploration of personal feelings, social support, problem-solving, goal setting, self-efficacy, and self-management (Funnell, 2010; Michele Heisler MD, 2007). It is widely used for health promotion regarding different focuses: Emotional support (including encouragement, reflection, reassurance, etc.), Appraisal support (including communication of information, motivation of target practice, etc.), and informational support (including the provision of knowledge relevant to problem-solving of target behavior). Inspired by prior research and our research findings, we intend to embed peer support into dietary technologies of healthy eating promotion as an approach that working-age individuals can use to help each other gain healthier eating practices. Specifically, we offer two aspects that enable peer support features through the design:

The first, **One-to-One Support**, focuses on encouraging a peer-bonding approach between two individuals at work. The paired individuals have similar eating goals and/or eating routines in the working context. Compared to general social support, a clear goal of task completion and having a "right" way to achieve it between two persons could better motivate people to help each other, bring satisfaction and pleasure, and improve engagement in using dietary technologies to stimulate personal healthier eating practices.

The second, **Group Support**, focuses on sharing health information in online or/and offline health communities to seek emotional support, accountability, and social support from pre-existing relationships in their working contexts. These communities could be social media platforms (Andalibi, Ozturk, & Forte, 2017; C. F. Chung et al., 2017) (e.g., Facebook and Instagram) or local occupational internal platforms. Additionally, the online platform could act as a social, photo-, and text-based food journal, which supports daily intake data collection, reflection on old posts, and finding peer help. Also, it could help people find others with the same interests and eating goals and discuss specific topics regarding healthy eating decisions and behaviors. Based on our experience, interpersonal interactions with others in the same workplace can influence the way people tracking their eating behaviors and their healthy eating decisions at work.

Design Implication 5: Incorporate Playful Features

The fifth implication of implementing playful interactions is to sustain healthy eating promotion and motivate users' interests while using dietary technologies. Throughout our research, we found that there have been extensive eating-related designs and tools on two types of technologies: (1) The first is a Mobile application that facilitates the progress of self-tracking by reporting daily intake, eating time, and duration manually as well as provide an overview of intake data history. (2) The second wearable system unobtrusively monitors eating status using sensors based on personal eating input and returns with feedback containing explanations of real-time eating data and improvement toward healthy eating suggestions. However, working-age individuals encountered many frustrations when interacting with these technologies in their daily working routines. The internal reasons for quitting the usage of these technologies are likely due to feelings of being

overburdened, repeated manual input of eating data, boring self-reporting process, etcetera. Thus, design principles for such technologies are recommended as interventions to promote healthy eating in the working context and add playful features or gamified elements to improve motivation and engagement for long-term use. Specifically, based on the five playful elements summarized by Mandryk et al. (Mandryk, Gerling, & Stanley, 2014), we propose four playful explicit design possibilities as follows:

Easy Entry into Use: Through encouraging explorative and playful using experiences for a shorter time with a more casual format, this design possibility is supported by game mechanics with low barriers that can be easily mastered by the user. For instance, designing a game process to learn the use of technologies, developing simple rules of intake reporting, making the interventions or technology visible during eating time in a daily working context, etc.

Achievable Short-Term Challenges: Although long-term challenges keep people focused and motivated, it might be difficult to achieve them without actionable short-term tasks. By separating a long-term challenge into smaller tasks, it would help individuals overcome the fear of the impossible to get things done, especially when they pay attention to tough working tasks. Moreover, short-term challenges should be attainable, which could stimulate enjoyment and engagement while using eating-related technologies.

Skill-Matching Challenges: The various levels of personal comprehensive ability and execution force regarding using technologies should be considered to bring comfort, satisfaction, and pleasure while using dietary technologies and also engage working-age individuals in the desired eating practice repeatedly in the daily working routine.

Appropriate Rewarding Experience on User's Effort: This design possibility features an immediate virtual or tangible reward based on individuals' eating performance (e.g., regular eating routine, eating on time, and healthy food choices) to sustain interests and boost confidence while interacting with dietary technologies and interventions.

Design Implication 6: Expand Possibilities of Multisensory Experience

The sixth implication, expected to expand possibilities of eating practices, is the provision regarding multisensory experience. According to our research, we proposed designing interactive tools or/and systems that offer multisensory experiences for a higher enjoyment of eating activity within our specific working context. Inspired by Neural technologies with sense augmenting for immersive eating and greater levels of physical and mental enjoyment during eating time, multisensory technologies, especially with the advancement of Augmented Reality (AR) systems, Virtual Reality (VR), Holographic technology, and 3D-printing technology, are widely used in Human-Food Interaction (HFI) field. With these technologies (in studies presented in Part IV), eating practice enables to be changed (Spence & Piqueras-Fiszman, 2013) regarding the 'visual characteristics' of food (e.g., texture (Okajima & Spence, 2011), color modified by AR (Narumi, 2016; Nishizawa et al., 2016) and VR (Bruijnes et al., 2016)), the 'sounds' (e.g., chewing sound (Zampini & Spence, 2004), environmental noise (Woods et al., 2011; Yan & Dando, 2015), music (Crisinel et al., 2012), eating sound interval (Kadomura et al., 2011), and interactive sounds with food (Kadomura et al., 2013)), and 'tactile interfaces' (e.g., for the lips (Tsutsui et al., 2016), for biting (Iwata et al., 2004), and for cutlery and tableware (Hirose et al., 2015; Spence, 2017)). In addition, different from the distributed approaches used in a working context, we intend to embed all technological tools for stimulating multiple senses in one interactive system design with concrete and real-life settings. In this way, working-age individuals could engage in expected healthy eating patterns unobtrusively when they focus on work tasks, so the efforts they have to pay for healthy eating can be further reduced. Also, we consider that the multisensory experience works not only to support healthy eating but also to comfort individuals by bringing relaxation and a break apart from tough working schedules in the working context. Furthermore, we encourage developing dietary technologies associated with different sensory augments since multisensory approaches would have a high expected growth rate and provide a potential foundation for high-level eating experiences in the future (Kita & Rekimoto, 2013).

8.3 Proposed Challenges

In this section, a conclusion of our knowledge learned throughout our research practices was presented to inspire future researchers to think ahead of potential challenges in the design of healthy eating promotion at work and conduct studies in more logical and robust ways.

The First Challenge regarding the Change of Working Context

It would be potential and interesting to involve the research focus on work-from-home and everyday living context in the development of healthy eating promotion. Due to the COVID-19 pandemic, an unprecedented number of working-age individuals have shifted from work-in-office to a work-from-home mode. During this special period, remote working online became a new normal worldwide and no longer an exception as before the pandemic. In other words, working in the office context will not be the single option for working-age individuals in the upcoming years. Therefore, it would be fruitful to investigate the multiple working modes and workplaces to create opportunities for promoting healthy eating during working hours.

In addition, workdays at home in COVID-19 times tend to change how individuals purchase and eat food compared to the office context, especially the cooking activity is also included in the eating process. Also, the easy access to food is higher than it is in the office context since the working space is much closer to an eating area like the kitchen at home. This could direct individuals to pay more attention to food but simultaneously raise the rate of consuming unhealthy food (e.g., sweet food, and snacks). Hence, we suggest that further research on healthy eating promotion at work could focus on both work-from-home and office contexts. Doing so would open the design possibilities and creation of space to facilitate healthy behavior during working hours and improve the overall vitality of health among working-age individuals.

The Second Challenge regarding the Target Users

Personalized promotion often means working-age users in an individual eating and self-monitoring activity, which may increase the risk of social isolation in the working context. Thus, we suggest that future dietary technology and intervention should be designed for both communities and tailored to individuals because social promotion among peers or co-workers in the office or family members at home can boost engagement in dietary technology and tools.

Yet, the recruitment of participants should be processed ethically. First, prior to the conducted studies, the introduction of designed activities and informed consent (contains such as information, the contact of the research institute and place where the study takes place, study procedures, duration, risks, potential benefits of the

study, the confidentiality issues regarding data collection, store, access, and analysis, rights to withdraw, etcetera) need be obtained. Therefore, the voluntary participants could fully understand the study without misthinking participation. Second, the data collection, storage and access, and potential use of data should be carefully considered and implemented to avoid unnecessary drop-offs. Specifically, researchers need to ensure data safety on secure computers, and only research team members have access to the collected data. Also, all demographic data should be anonymously sorted and treated confidentially. Moreover, the presentation of data can only be used in academic publications with confidentiality as well.

The Third Challenge regarding the Consistent Language within Multidisciplinary Fields for Healthy Eating Promotion

Throughout our research journey in this dissertation, we found that there is little consistent language for designers, nutritionists, technology developers, and data scientists who all work in the eating-related research field to transfer their knowledge and information. These various-field researchers work independently and have used well-developed approaches and tools to benefit healthy eating practices in their research directions. However, there has great potential to group them and benefit significantly from each other. As design research of healthy eating promotion developed later in the field with dietary technologies and interactive tools, we encourage designers firstly to understand the underlying knowledge of nutritional expertise, technological implementation, dietary data collection, and data analysis. Then, they enable the transfer of such knowledge from other expertise to practical design concepts and interventions. We also suggest implementing and exploring transferred design outcomes in real-life working contexts to acquire valuable feedback from target users. In this way, designers and/or researchers can control the potential unhelpful promotion and optimize helpful interventions to stimulate healthy eating in the working context.

The Fourth Challenge regarding the Collaborative Ideation between Users and Designers for Developing Concepts for Food Technologies

The fourth challenge is promoting the collaboration between designers and potential target users in the design process. Increasing evidence has illustrated the value of participatory research that engages target users with non-design background in the design process of developing food technologies and interventions. A key value of involving non-design users is seen as residing in "expertise by experience" (Lushey & Munro, 2015). Individuals without formal design backgrounds can be significant contributors to the development of food technologies and health-related interventions. Their perspectives, skills, knowledge, and personal eating experiences can serve as valuable sources of inspiration for designers when creating user-centered concepts. However, target users are not treated equitably during the design process because they have limited participation in developing concepts and learning about the design process. Thus, we suggest implementing participatory approaches that engage both users and designers by initially encouraging future users to envision future food technologies via storytelling narratives, then sharing the narratives with designers to inspire them to develop more imaginative and creative design concepts. As an illustrative example, we have introduced a Collaborative Ideation Approach in Chapter 6. This approach has been tested as a beneficial means for developing high-level creative concepts. We believe that this implication and approach can provide valuable insights for designers and researchers in the HFI field, particularly in terms of envisioning innovative technologies and solutions.

APPENDICES

Chapter 3:

Appendix A-1: Questionnaire of the User-Centered Inquiry Study

Appendix A-2: Technology Acceptance Model (TAM) Used in the User Study with EAT@WORK Prototype

Chapter 4:

Appendix B-1: The NASA Task Load Index (NASA-TLX) Used in the Traqq App Study

Appendix B-2: The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) Used in the Traqq App Study

Chapter 5:

Appendix C-1: The NASA Task Load Index (NASA-TLX) Used in the NutriColoring Study

Appendix C-2: The Intrinsic Motivation Inventory (IMI) Used in the NutriColoring Study

Chapter 6:

Appendix D: The Creative Product Semantic Scale (CPSS) Used (for Evaluating Design Concepts) in the Collaborative Ideation Study

Appendix A-1: Questionnaire of the User-Centered Inquiry Study

My Food Intake Stories at Work

My Lunch Story in the Office

In my workdays

- I normally have lunch at/in (place & time) ____________
- I normally have lunch with (who) ____________
- I choose to eat lunch like this, because ____________

For my workday lunch

- I prefer to eat ____________
- Normally, I get food for lunch from ____________
- I prefer to get food like this, because ____________

From my perspective

- Workday lunch brings me benefits, such as ____________
- It has these benefits, because ____________

How I lunch in my workdays can be influenced by ____________

Technology

Track and manage food intake

- Track and manage diet for me is ____________
- I have these feelings, because ____________

My experience of using tools

- Normally, I have tried to track and manage my diet using tools, such as ____________
- My experience of using these tools is ____________
- I have these feelings, because ____________

If there was a technology that can help me track my daily intake

- It could be a technology, such as ____________
- It can help me track intake through ____________
- It would bring me ____________

My Snack Story in the Office

During my working time

Normally, I prefer to get snacks from ____________________

I choose to get snacks in this way, because ____________________

My frequency of taking snacks in the office

How many times ____________________

How long per each time ____________________

I take snacks like this, because ____________________

When I take working snacks

I prefer to eat ____________________

I choose these snacks because ____________________

While I am snacking, I prefer to ______________________ at the same time

My snacking at work can be influenced by ____________________

Demographic

With what gender do you identify ☐ Male ☐ Female

How old are you? ____________________

What is your nationality? ____________________

What is your level of education? ____________________

What is your occupation? How long have you been working? ____________________

Is there anything else we should know about your responses of eating habits at work? ____________________

Could we know your weight and height? (optional) ________kg/_________cm

Appendix A-2: Technology Acceptance Model (TAM) Used in the User Study with EAT@WORK Prototype

Please rate your using experience of EAT@WORK app. For each of the following statements, please indicated how likely it is for you using the following scale:

1	2	3	4	5	6	7
Extremely likely	Quite likely	Slightly likely	Neither likely nor unlikely	Slightly unlikely	Quite unlikely	Extremely unlikely

1. Using EAT@WORK during my working hours would enable me to accomplish tracking my food intake more quickly.

Extremely likely 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Extremely unlikely

2. Using EAT@WORK during my working hours would improve my eating performance.

Extremely likely 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Extremely unlikely

3. Using EAT@WORK during my working hours would promote my healthy eating behaviors.

Extremely likely 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Extremely unlikely

4. Using EAT@WORK during my working hours would enhance my effectiveness on healthy eating.

Extremely likely 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Extremely unlikely

5. Using EAT@WORK during my working hours would make it easier to track my daily food intake.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

6. I would find EAT@WORK useful during my working hours.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

7. Learning to operate EAT@WORK would be easy for me.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

8. I would find it easy to get EAT@WORK to do what I want it to do.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

9. My interaction with EAT@WORK would be clear and understandable.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

10, I would find EAT@WORK to be flexible to interact with.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

11. It would be easy for me to become skillful at using EAT@WORK.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

12. I would find EAT@WORK all easy to use.

Extremely likely	1	2	3	4	5	6	7	Extremely unlikely
	○	○	○	○	○	○	○	

Appendix B-1: The NASA Task Load Index (NASA-TLX) Used in the Traqq App Study

Performance

How successful were you in accomplishing what you were asked to do?

Very Low — Very High

Mental Demand

How mentally demanding was the task

Very Low — Very High

Frustration

How insecure, discouraged, irritated, stressed, and annoyed were you?

Very Low — Very High

Appendix B-2: The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) Used in the Traqq App Study

Please rate your using experience of Traqq app. For each of the following statements, please indicated how agree it is for you, using the following scale:

1	2	3	4	5
Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree

1. I have the resources necessary to use Traqq app.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

2. I have the knowledge necessary to use Traqq app.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

3. Traqq app is compatible with other technologies I use.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

4. I feel comfortable using Traqq app for tracking my intake during working hours.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

5. Using Traqq app for tracking my intake during working hours is fun.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

6. Using Traqq app for tracking my intake during working hours is enjoyable.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

7. Using Traqq app for tracking my intake during working hours is very entertaining.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

8. The use of Traqq app has become a habit for me.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

9. I am addicted to using Traqq app for tracking my intake during working hours.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

10. I must use Traqq app for tracking my intake during working hours.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

11. Using Traqq app for tracking my intake during working hours has become natural to me.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

12. I intend to continue using Traqq app for tracking during my working hours in the future.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

13. I will always try to use Traqq app in my daily working life.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

14. I plan to continue to use Traqq app frequently.

	1	2	3	4	5	
Strongly agree	○	○	○	○	○	Strongly disagree

Appendix C-1: The NASA Task Load Index (NASA-TLX) Used in the NutriColoring Study

Mental Demand — How mentally demanding was the task

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed were you?

Very Low — Very High

Appendix C-2: The Intrinsic Motivation Inventory (IMI) Used in the NutriColoring Study

Please rate your using experience of NutriColoring toolkit. For each of the following statements, please indicated how true it is for you, using the following scale:

1	2	3	4	5	6	7
Not at all true			Somewaht true			very ture

1. While I was working on the task I was thinking about how much I enjoyed it.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

2. I did not feel at all nervous about doing the task.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

3. I put a lot of effort into this task.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

4. I believe that doing this task could be of some value for me.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

5. I think I am pretty good at this task.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

6. This task did not hold my attention at all.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

7. I felt tense while doing the task.

Not at all true 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ Very true

8. I think that doing this task is useful for motivating my self-reflection on my daily intake.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

9. I think I did pretty well at this task, compared to others.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

10. Doing the task was fun.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

11. I felt relaxed while doing the task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

12. I think this task is important for my health and wellbeing.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

13. I enjoyed doing the task very much.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

14. I didn't try very hard to do well at this task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

15. I would be willing to do this again because it has some value to me.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

16. I am satisfied with my performance at this task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

17. I was anxious while doing the task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

18. I thought the task was very boring.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

19. It was important to me to do well at this task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

20. I think doing this task could help me to pay attention to my intake during working hours.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

21. I felt pretty skilled at this task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

22. I thought the task was very interesting.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

23. I felt pressured while doing the task.

	1	2	3	4	5	6	7	
Not at all true	◯	◯	◯	◯	◯	◯	◯	Very true

24. I didn't put much energy into this task.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

25. I believe doing this task could be beneficial to me.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

26. I would describe the task as very enjoyable.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

27. I tried very hard on this task.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

28. I think this is an important task.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

29. After working at this task for a while, I felt pretty competent.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

30. This was a task that I could not do very well.

	1	2	3	4	5	6	7	
Not at all true	○	○	○	○	○	○	○	Very true

Appendix D: The Creative Product Semantic Scale (CPSS) Used in the Collaborative Ideation Study

Please assess each design concept for food-tech futures by ticking one circle per line.

	1/7	2/6	3/5	4/4	5/3	6/2	7/1	
Usual	○	○	○	○	○	○	○	Unusual
Operable	○	○	○	○	○	○	○	Inoperable
Astonishing	○	○	○	○	○	○	○	Commonplace
Functional	○	○	○	○	○	○	○	Nonfunctional
Surprising	○	○	○	○	○	○	○	Customary
Fresh	○	○	○	○	○	○	○	Overused
Necessary	○	○	○	○	○	○	○	Unnecessary
Original	○	○	○	○	○	○	○	Commonplace
Astounding	○	○	○	○	○	○	○	Common
Unfeasible	○	○	○	○	○	○	○	Feasible
Inappropriate	○	○	○	○	○	○	○	Appropriate
Usable	○	○	○	○	○	○	○	Unusable
Novel	○	○	○	○	○	○	○	Predictable
Inadequate	○	○	○	○	○	○	○	Adequate
Ineffective	○	○	○	○	○	○	○	Effective
Inessential	○	○	○	○	○	○	○	Essential
Useful	○	○	○	○	○	○	○	Useless
Revolutionary	○	○	○	○	○	○	○	Average

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CURRICULUM VITAE

Biography

Sibo Pan was born on the 02nd of September 1992, in Dalian, Liaoning Province, China. In 2015, she received the bachelor's degree in the Department of Industrial Design at the China Academy of Art (CAA) in Hangzhou, China. After graduating in July 2015, she started her master's program in Sustainable Design in the Department of Product Design at Bauhaus-Universität Weimar, Germany. During her master period, Sibo continued developing her skills as a product designer in master training as well as a number of commercial design projects. Meanwhile, she became an illustrator and published her works in Bauhaus University Journal in 2018. Next to her studies, she was a product designer (2018-2020) of iBranco Studio in Zhuhai, China.

After the master graduation, Sibo started her PhD research in the Industrial Design department at the Eindhoven University of Technology (TU/e) in 2018. In her work, she focused on designing digital tools for promoting healthy eating at work. During her PhD, Sibo has been involved in a research program called "Pride & Prejudice" conducted by Eindhoven University of Technology, Delft University of Technology, University of Twente, and Wageningen University. Also, she participated in a future food design project collaborating with Future Laboratory at Tsinghua University, China. Her PhD research was carried out under the supervision of prof. dr. Steven Vos, prof. dr. ir. Aarnout Brombacher, and dr. Xipei Ren. This thesis is the result of her PhD research on the topic of "Exploring Design Opportunities for Promoting Healthy Eating at Work".

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Publications

Journal articles:

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