

Master thesis

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An Interactive & Hands-free Instruction-based Cooking Experience

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Summary

Cooking is an essential part of most people's day-to-day lives. It is a dynamic activity that involves multitasking, timing of tasks, and flexibility. However, the available instruction methods for cooks who wish to follow recipes are quite rigid and linear. This project aims to create a design solution that provides instructions in a way that is in better accordance with natural cooking behaviours.

Chapter 1 introduces the project, its scope, and explains the methods and project approach. The scope of the project is to deliver a conceptual instruction-based cooking tool that utilizes Artificial Intelligence. While designing the solution, speculative design methods are considered in order to design for the near future. It is designed for a future where tasks in recipe instructions can be used more flexibly in digital products and Human Activity Recognition can accurately recognize complex cooking actions with mobile devices. The design solution has been created for a company called Verdify. Verdify is a food tech company with products that aim to allow users to achieve fully personalized nutrition. Swapmeals is their recipe platform that allows users to swap ingredients to fit their dietary needs while adjusting instructions accordingly and maintaining flavor profiles. The design solution aims to ultimately live on this recipe platform. The project is executed with a User-centered Design approach which involves end-users in the design process in order for them to have an impact on their final product.

Chapter 2 strives to understand the users' context. The users were observed while cooking with instructions in order to understand the pain points that should be designed for. The most prevalent and significant themes that emerged from the study were that users experience cognitive overload while cooking and often experience uncertainty in the cooking process. In chapter 3, academic design solutions and commercial products for hands-free instruction-based cooking were reviewed to understand which issues, discovered in the context research, have not been designed for. This gap is used to specify design requirements (chapter 4). The requirements specify that the design solution should allow home-cooks to use recipe instructions in a way that is hands-free, non-linear, informative, and that minimally interrupts the cooking flow along with reducing their cognitive load and the associated negative emotions. The solution is also required to allow the user to mainly focus on the task at hand; the device should manage the remaining responsibilities. Lastly, the research discovered that the design solution should create the experience of cooking a new recipe similarly to how one would cook a familiar recipe.

Chapter 5 explores solutions that meet the specified requirements. The exploration led to 2 contrasting concepts that aim to improve instruction-based cooking in a familiar textual manner and an innovative experiential manner. These 2 concepts were tested with users in chapter 6 in order to compare the newly defined interaction methods and understand which interactions are desired in the various moments of the cooking process. The results generated an iterated list of requirements to be applied to the final design.

Chapter 7 introduces the conceptual instruction-based cooking design solution: a user interface that utilizes Human Activity Recognition for user-to-product communication. The tool adopts the cognitive load from its users by managing timing and their progression while adjusting to the user's autonomous adaptations to the recipe. The design solution is an interactive, hands-free, and informative recipe instruction solution. It allows home-cooks to let go of keeping an overview of the cooking process and instead solely focus on the task at hand, allowing cooking to be a worry-free and enjoyable activity for even the tensest home-cooks.

Terminology

Artificial Intelligence (AI)

"The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." (Oxford Languages, n.d.)

Augmented Reality (AR)

"A technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view." (Oxford Languages, n.d.)

Concurrent Think-Aloud (CTA) Protocol

When participants are asked to narrate their thoughts aloud while carrying out tasks.

Human Activity Recognition (HAR)

"The art of identifying and naming activities using Artificial Intelligence (AI) from the gathered activity raw data by utilizing various sources." (Gupta et al., 2022)

Fine-grained HAR

HAR that "focuses on recognizing event- or action-level activities." (Hu et al., 2020)

Internet of Things (IoT)

"The interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data." (Oxford Languages, n.d.)

Retrospective Think Aloud (RTA) Protocol

When participants are asked to reflect on the thoughts they had while performing tasks, after they have completed the tasks.

Speculative Design

"Us[ing] design as a means of speculating how things could be." (Dunne, 2013)

User-centered Design (UCD)

"An iterative design process in which designers focus on the users and their needs in each phase of the design process." (Interaction Design Foundation, n.d. *User Centered Design*)

User Interface (UI) Design

"The process designers use to build interfaces in software or computerized devices." (Interaction Design Foundation, n.d. *User Centered Design*)

User Journey Map

"A visualization of the process that a person goes through in order to accomplish a goal." (Gibbons, 2018)

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01 Introduction

This chapter provides the background information of the project, a description of the project approach, and the project phases.

Project Background

The following section presents a brief description of the project as well as how it developed into a thesis project.

Project Description

This project is about creating a product that provides recipe instructions to home-cooks in a manner that is more in accordance with natural cooking processes. Current conventional recipe instruction methods, such as cookbooks and cooking videos, typically follow a linear step-by-step process. Yet cooking commonly involves switching attention between several tasks, precise timing, and depending on the cook, the order in which the tasks are completed may differ from the order presented in the instructions (Hashimoto & Yamakata, 2008). Maintaining a clear overview of the simultaneous tasks and their relationships with each other can cognitively overload the home-cook and lead to negative cooking experiences.

The project began with the assumption that switching between simultaneous tasks while cooking led to cognitive overload, that having to interact with recipe instructions with your hands interrupts the cooking flow, and that not every step or instruction is useful or necessary for the user or there is not enough elaboration. These assumptions form the starting point for why there is an assumed need for this project.

The project utilizes Artificial Intelligence (AI) and user interface (UI) design to provide cooking instructions in a manner that is non-linear and minimally obtrusive to the cooking process. AI is rapidly becoming more prominent in people's every-day lives. It is used to improve the accuracy in detecting health conditions as well as in platforms such as Netflix and Spotify (Holt, 2018). AI can monitor the user's behaviour and make recommendations based on these observations. Within the domestic home, smart speakers are becoming increasingly popular, with 35% of Americans aged 18+ claiming to own one in a 2022 survey (The Smart Audio Report, 2022). Smart speakers, such as Google Assistant, use voice assistance technology to allow users to verbally ask for and receive assistance (Google, 2023). Commands range from "Set a timer for 15 minutes" to "Turn the lights off" depending on which smart home devices it is connected to. Artificial Intelligence is creating a more efficient society (Holt, 2018); this research explores how it can do so in the context of instruction-based cooking.

Stakeholders

The project was carried out in collaboration with Delft University of Technology (TU Delft) and Verdi Food B.V. (Verdify). Within TU Delft, the project exists within the Expressive Intelligence Lab. The Expressive Intelligence Lab aims to shape the future of AI in a human-centered and impact-driven way (Expressive Intelligence Lab, n.d., *What is the Expressive Intelligence Lab?*). Verdify is a food tech company that aims to enable people to make better food choices for personal and planetary health (Verdify, n.d., *About*). The project will deliver a design solution that will ultimately exist on Verdify's Swapmeals platform. Swapmeals is a recipe platform that allows users to swap ingredients in order for them to fit the user's dietary needs. Verdify was presented the project idea.

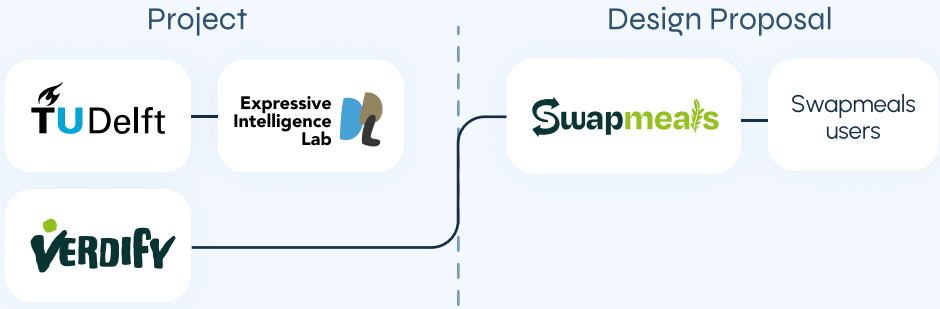


Figure 1. Diagram of the stakeholders regarding the project and design proposal

Project Overview

The following section explains how the project was executed. It includes the scope, approach, and outcomes.

Scope

The project aims to deliver a design proposal that is realistically feasible in the near future: approximately 5 years. This timeline is determined by Verdify's current research and vision. Methods from speculative design are used to imagine how the instruction-based cooking experience could be improved without completely being limited to current technology and society's acceptance (Dunne, 2013). However, the design proposal should make use of technology that is expected to be viable in the near future. Since the technology is not yet fully feasible, the final deliverable will be presented in a conceptual manner. The artificial intelligence required to create the intended user-product interactions will be briefly explained to prove the feasibility. However, explaining the technological specifications in depth has been left out of the scope. The conceptual proposal should communicate the interaction methods between the user and the product in order to explain the intended interaction experience. It should also outline the proposed design features. However, detailed user flow charts have been excluded from the scope as these are solely necessary during development. Lastly, suggestions are provided to allow Verdify to provisionally create a design solution with currently available technology.

Approach

The project utilizes a User-centered Design (UCD) approach. UCD is an iterative design approach where the users needs are addressed in every phase of the design process (Interaction Design Foundation, n.d. *User Centered Design).* The approach is frequently attributed to Donald Norman, who wrote *User Centered System Design: New Perspectives on Human-Computer Interaction* (1985) and *The Design of Everyday Things* (1988).

This project utilized UCD approaches in 2 main iterative phases: a research phase and a design solutions phase. The end-users are involved in both phases of the project to ensure that their needs are understood and that they are able to influence the final design solution (Abras, 2004). This is to ensure that the proposed design is a product that users verily need and value.

Phase 1: Research

The first phase of the project was about carrying out research that allowed for design requirements to be generated. The phase started with context research in order to understand the user's context of use. The research was executed in users kitchens and aimed to understand what problems they face while cooking with recipe instructions. The second part of the research phase consisted of exploring current instruction-based cooking solutions. This review looked into both academic design solutions and commercial products. The results from the context research and current solutions formed as the foundation to specify the design requirements and thus generate the solution space.

Phase 2: Design Solutions

The second phase of the project used the insights and requirements from the research phase to produce a design solution. The phase started with an exploration into design solutions. This consisted of investigating relevant technology and ideating on how the user and the product could interact with each other in various moments of the cooking process. This was an iterative period of the project where concepts were generated and assessed against the initial requirements. The results and insights were then translated into new design requirements that were used to create the final design proposal.

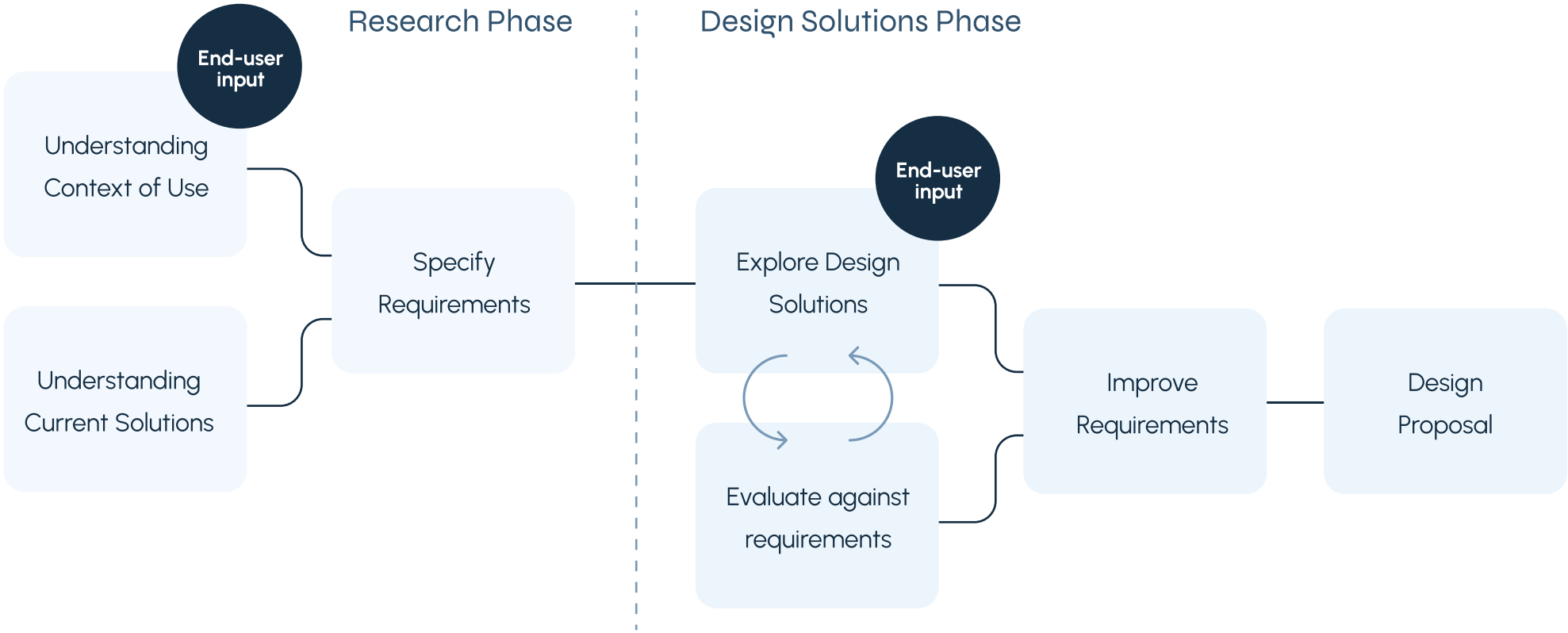


Figure 2. Diagram of the project process within the phases

02 Context Research

The objective of the context research is to gain a deep understanding of the context of users interacting with their cooking instruction method in order to improve the experience. This will be achieved by interviewing and observing the instruction-based cooking experience. This knowledge, in turn, will be used to pinpoint the pain points and design opportunities. The findings will be presented as a visual user journey map for each participant in order to organize the information and outline the insights. The insights will be coded to facilitate cluster analysis and the formulation of themes to identify commonalities between user experiences while cooking with instructions.

Introduction

Limited information can be found on how users interact with traditional recipe instruction methods. There is little research regarding which problems they face or what process advancements will improve their user experience and why. There have been several attempts to improve the current methods of following recipe instructions. However, they lack user-centric research that explores the issues that users actually face and instead propose solutions that solve assumed problems. Their research validates their solutions without fully exploring the users expectations of a utopian instruction-based cooking experience and whether the solution aligns with this expectation. One paper states that using a cookbook can distract the user from the process of cooking (Bradbury, Shell, & Knowles, 2003). However, it does not explore to what extent using a traditional cookbook interrupts the cooking experience and whether this is perceived as a negative aspect of the experience by the user. Additionally, they claim that cookbooks can create a stressful experience due to potentially difficult cooking terminology, time sensitive tasks, and conflicting direction of the user's attention. This can be seen as a legitimate claim due to insights from one's personal cooking experiences, however, the research to support this claim is lacking.

Another study, by Buykx (2011), provides valuable insight into how textual instructions can be presented to users in a clear and understandable manner. The study compares 3 types of textual recipe instruction delivery with each other. It discovered that instructions that are broken down into their most basic components are interpreted as clearer and easier to understand. Additionally, this form of instructions sped up the cooking process in 2 of the 3 recipes tested. The 3 types of instruction delivery are as follows: 1.) Control: original text from a cookbook, 2.) Simple step-by-step format: the same instruction text, broken up into steps, 3.) Edited step-by-step format: simple step-by-step format with ingredient preparation & quantity included, and logical reordering of the steps. The research explained how cooking requires knowledge and skills in planning organizing, and monitoring and how cooking with a recipe can eliminate some of these problems (Buykx, 2012). However, they also proved that decreasing these problems comes at the expense of increased cognitive workload due to having to put effort into understanding the instructions as well as switching their attention between them and the cooking tasks. This is combined with managing simultaneous tasks and interruptions. They discovered that home-cooks use recipes flexibly and that the users wanted a detailed overview of the recipe as well as detailed step-by-step instructions. That being said, its findings are limited to the way in which users interact with text and lack insight into how users interact with or would like to interact with their devices as well.

In conclusion, there are several assumed problems that occur while cooking with instructions. However, the claims are often not supported by research. Buykx (2011) aimed to close this gap by exploring the interaction between users and 3 varying textual instruction templates. Useful findings were generated regarding user-instruction interactions. However, the research lacked insights into user-device interactions. Additionally, they explored how cognitive load can be minimized with textual instruction, yet did not explore how an instructional product could minimize the overload with regard to managing and switching their attention between tasks. Extensive research into the users complete cooking experience while using instructions is lacking. For this reason, this project has executed explorative context research in order to close this gap.

Method

The purpose of carrying out this context research is to identify pain points regarding current instruction-based cooking methods and obtain a deeper understanding of cognitive overload and multitasking while cooking. This is done by conducting exploratory research that utilizes a mixed method techniques in order to uncover what people say and do (Sanders & Stappers, 2012). The approaches are user-centered and aimed at diving deeper into the user's context in order to gain a more insightful understanding of their needs, expectations, and perspectives. This user context research conducted for this study uses an interview to hear what the users have to say about their cooking experience in combination with an observation session to see what they actually do. The initial interview is used to understand their demographics as well as how they describe their standard cooking experience. It is followed by an observation session, where the users are observed while cooking, in order to perceive their interaction pain points and opportunities for creating a better experience. The study session is concluded with a final interview which allows participants to reflect on the cooking experience. This is to understand if it was a normal session and where they personally saw room for improvement, in order to compare their perceptions to those of the observer.

Ethical Considerations

The research was first approved by the Human Research Ethics Committee (HREC) at TU Delft. The process consisted of completing an HREC checklist (appendix B), creating an informed consent form (appendix C), and constructing a data management plan in order to minimize risks regarding research with human participants in order to test in a safe and ethical manner. The participants were asked to consent to audio recording and filming of the sessions.

Participants

The context research was completed with a total of 7 participants in 5 kitchens (2 couples). The participants are aged between 26 and 59 years old and consist of 5 females and 2 males (see table 1). The participants are recruited through personal connections. Every participant possesses a post-secondary education with careers in fields such as healthcare and education.

Age	26	28	26	26	30	58	59
Gender	Female	Female	Female	Female	Male	Male	Female

Table 1. Age and gender of participants - not in chronological order as to protect their identities

Procedure

Before meeting the participants at their houses to begin the research, they were asked to prepare a preferred recipe that they might use on a regular evening. They were told that the recipe should be one they have never used before. This is to accurately replicate their regular cooking experience while enforcing attentiveness to instructions that is unaffected by prior knowledge. This is done in order to affectively observe the interaction between the user and their recipe instructions. Pulling from prior knowledge is not completely avoidable as users may have cooking skills that impact the interactive flow of the task at hand. Yet, using a new recipe should minimize this. The participants are asked to share their intended recipe for reference. The process begins with an opening interview, followed by passively observing the user cook with their preferred recipe and device, and ending with a closing interview.

Session Opening

The participant was asked to read and sign the informed consent form and give permission for audio and video recordings. Afterwards, the researcher explained the contents of the study, approximately how long it would take, and let the participants ask questions.

Preliminary Interview

The participant was then asked 10 questions in order to understand their general cooking context. Specifically, the aim was to understand their current reliance on recipes, fluency in cooking, and cooking enjoyment. This information can be used to generate more accurate insights from the observation sessions. The interview uses a structured interview (Kumar, 2018) approach and consists of 10 closed and open-ended questions, as seen to the right. Questions 4 and 5 were asked to get an idea of how often they follow recipes as this can indicate a certain "fluency" in instructional cooking. Question 6 is asked as a way of assuming how reliant they are on the instructions versus own skills. Question 7 is asked in order to see if the participants would need specific recipes or change out ingredients often. They were asked what their usual cooking method is in order to understand if cooking with instruction reflects their usual routine. Lastly, they are asked how much they enjoy cooking to better interpret the emotions observed while they cook. All interviews were audio recorded with the participant's permission.

01 What is your age?

02 What is your gender?

03 What is your education / occupation?

04 How many recipes do you follow per week?

05 How many hours per day do you cook for?

06 How would you assess your cooking skills?
(Novice, advanced beginner, competent, proficient, expert)

07 Do you have any dietary restrictions?
(Or cook for someone who does?)

08 How do you usual cook (with or without instructions)?
- Do you prefer cooking with or without instructions?

09 Do you usually cook alone or with someone else?
- How would you describe cooking with someone else?

10 How much do you enjoy cooking?
(Not at all, not very much, somewhat, quite a bit, very much)

Observation Session Opening

After the preliminary interview, the video recording device was set up to start the cooking session. The participants were asked to think aloud as they cooked and try to imagine that they are not being observed. The researcher set up to take notes in an unobtrusive location in the kitchen.

Observation Session

Once the participant and researcher have set up, the participant started cooking and the observation session began. The participants were asked to think aloud while cooking. This technique is called the concurrent think-aloud (CTA) protocol, and it aims to understand the users real-time thoughts, difficulties, and justifications (Chee, 2019). The CTA protocol provides real-time insights from the user's perspective that may be missed from observing alone. While the users cooked they were observed in a non-participant observation (Kumar, 2018) manner, where the observer was passive and did not participate in the cooking. This is because observation strives to occur under natural conditions, where the activity is not disrupted. However, the CTA protocol and the awareness that the researcher is observing them may cause the participant's behaviour to differ from their usual context (Kumar, 2018).

The researcher took notes during the session using a custom-made note template (figures 4 & 5). The note sheet was created to more efficiently track emotions while carrying out tasks and the extent of multitasking. The user's thoughts and emotions were captured in a qualitative manner using narrative recording, where the interactions were described in the words of the researcher (Kumar, 2018). The thoughts and emotions were captured to map out the user's experience.

The cooking sessions were video recorded in order to avoid missing information that could not be observed during the experiment, as the observer took comprehensive notes during the process.

The observations allowed for information about the user's behaviour to be captured in a way that is not possible to do so from an interview (Kumar, 2018). The participants may not be consciously aware of the issues they experience and need to be in the context to share this information. This method was used to understand the user's behaviour in addition to the perceptions as obtained in the interview.



Figure 3. A participant during the observation session

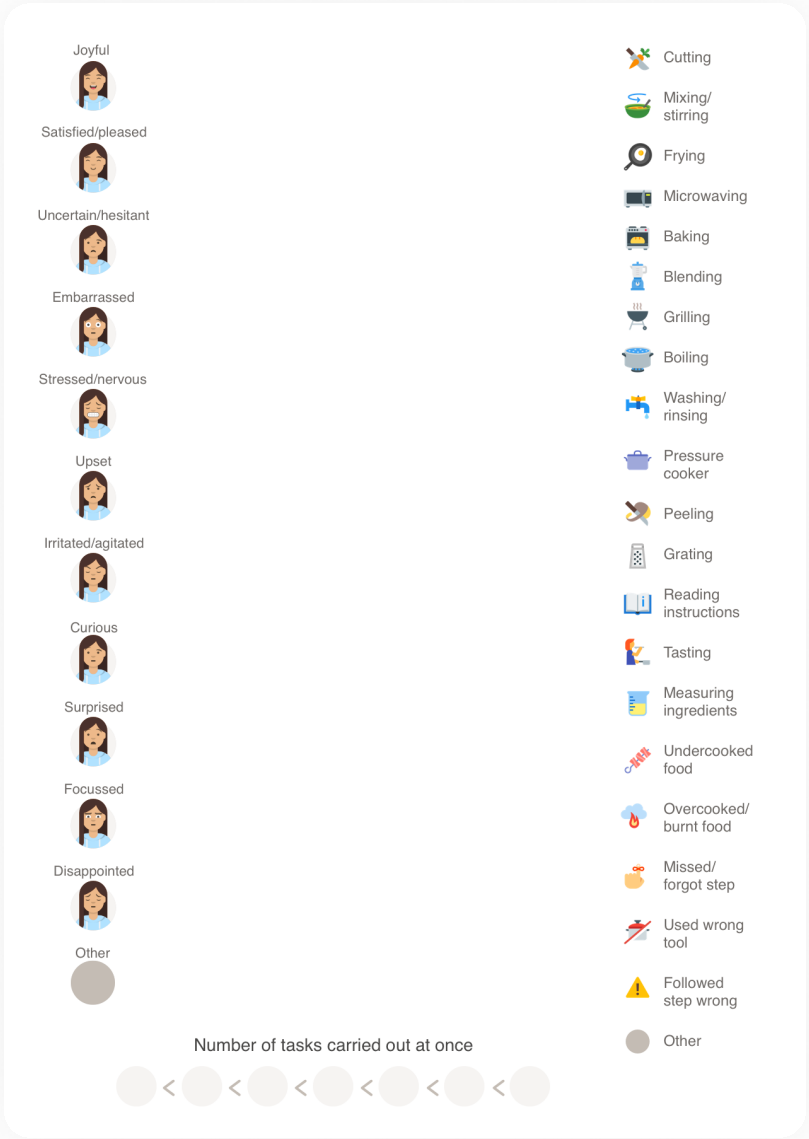


Figure 4. Note sheet template used during observation sessions in order to keep notes of emotions in relation to tasks as well as how many tasks were carried out at once.

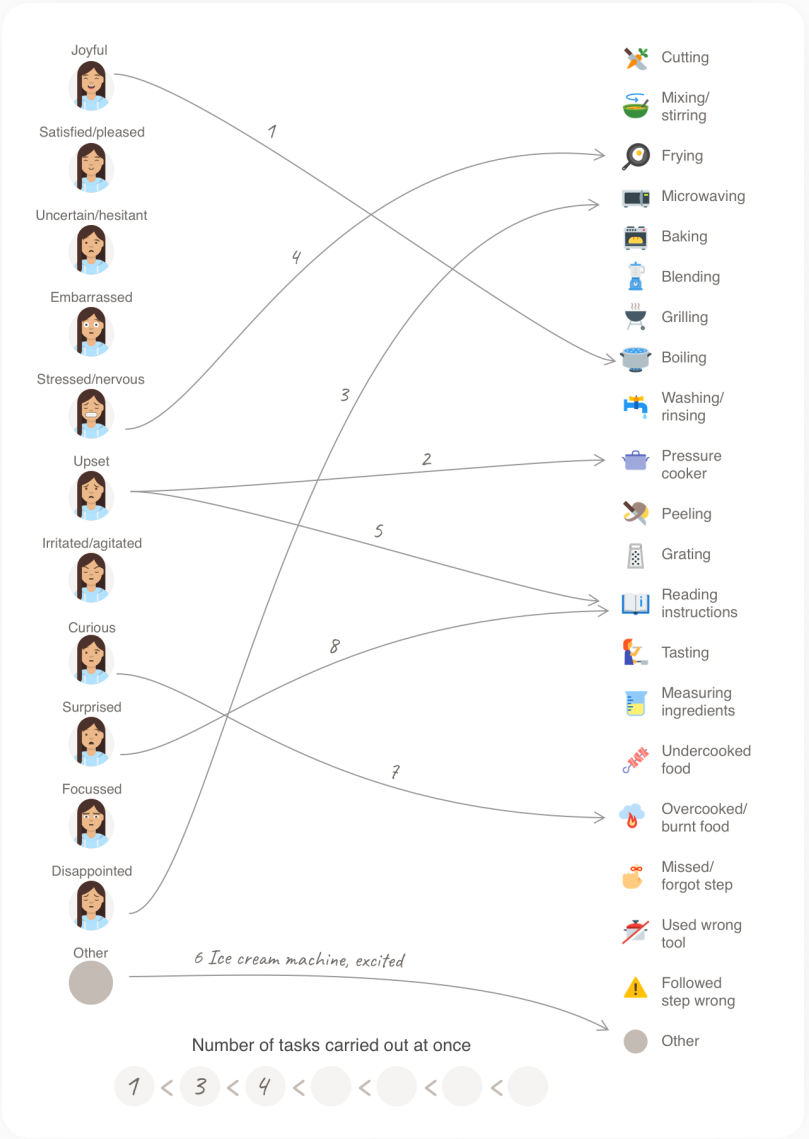


Figure 5. Example of a what a filled in notes sheet could look like

Closing Interview

After the observation session, the participants were asked 4 open-ended questions in a closing interview. This was to allow the user to reflect on their cooking experience in a non-restrictive manner. Its aim is to validate the observations, understand how this experience compares to their average cooking experience, and find out how they think their cooking experience could be improved. Their answers were also audio recorded. The questions do not mention technology or AI intentionally so as not to sway or limit the users answers.

01 How would you describe this cooking experience?

02 How could this experience have been improved?

03 What support would you have liked while cooking?

When and why?

04 Which cooking style(s) do you identify with?

The cooking styles mentioned in question 4 (and illustrated to the right) refer to Relationships's Australia CEO, Elisabeth Shaw's 5 different cooking types. The first cooking type is the Hungry Hustler, which 29% of Australians identify as. The Hungry Hustler leads a busy life and therefore only has time for quick and easy meals. The second is the Balance Seeker (25%) who want to eat healthy and varied meals that account for all the dietary needs and preferences of their household. Next, the Curious Cook (24%) enjoys playing around with new recipes, ingredients, cuisines, and techniques. In contrast, the Life Learner (9%) can sometimes find the cooking experience quite stressful. They can find cooking overwhelming and worry about the end result. Lastly, the Proud Plater (7%) takes pleasure in cooking for others and takes pride in impressing their company with what they have made. These cooking styles are chosen to be in the closing interview as they provide deeper insight into what kind of cook the user identifies as. This could allow for their needs to be better designed for, determine an appropriate target user group, and/or validate insights for the observation study.

Session Wrap-Up

The sessions were concluded by thanking the participants for taking part and leaving them to enjoy their meals.



Hungry Hustler



Balance Seeker



Curious Cook



Life Learner



Proud Plater

Analysis

To allow for the collected data to be analyzed, it is first translated into appropriate forms:

01 The 46 minutes and 26 seconds of audio recordings from the interviews were transcribed from speech to approximately 31 pages of text (new line when switching speakers)

- Relevant Dutch text was translated to English

02 The emotions observed were outlined in relation to the associated cooking task

- These were extracted from the notes taken during the observations and from reviewing the video footage

03 How many times the user referred to their recipe instructions device was extracted from the video footage

04 The number of multitasks that occurred at a given time was extracted from the notes pages

Recipes & devices

The 5 recipes and the devices the participants used to follow these recipe instructions were chosen by the participants themselves. The recipes vary from pancakes to paella. 5 of the 6 recipes follow a 'control' recipe format as described by Buykx (2011) from the related research. 1 of the recipes is in a simple step-by-step format. The number of tasks in each recipe is calculated in order to translate them all into the same instruction format, simple step-by-step. This is to accurately compare recipes (see table 2). The table also provides a summary of how long the recipe is estimated to take, if the recipe contained images, and how many instructions the original recipe contains.

	Quick chinese scallion pancakes	Butternut squash risotto With frizzled sage and brown butter	Paella with chicken and shrimp	Fried miso eggplant with rice	Baked trofie
Device used	Smart phone	Smart phone & Google Nest display (for timers)	Smart phone	Smart phone	Laptop
Estimated cooking time (min)	25	60	25	50	60
Type of instruction steps (As described in Buykx, 2011)	Control	Control	Control	Control	Simple step-by-step
Images in instruction steps	✗	✓	✗	✗	✓
Number of steps:					
As defined in recipe	4	11	2	8	18
Translated to step-by-step format	7	22	10	13	18

Table 2. Overview of the participants selected recipes

Transcribing Interviews

The interviews were transcribed from speech to text in order to simply refer back to the dialogue so that messages of what users wanted to convey could be extracted. These messages were used in the journey maps. The speaker is identified in the transcriptions to easily determine which speaker the text refers to. The transcribed answers from the preliminary interview, with the exception of the participants age, gender, and occupation, can be seen in table 3. This demographic information has been excluded for privacy reasons.

	Participant 1	Participant 2	Participants 3		Participant 4	Participants 5	
Recipes per week	4	6	5	5	2 or 3	3 or 4	3 or 4
Time spent per day (hours)	1	0.5	0.5	0.5	1	Week = 1, Weekend = 2-3	Week = 1, Weekend = 2-3
Cooking level	Proficient	Proficient	Competent	Competent	Proficient	Expert	Proficient
Dietary restrictions	No	No	Low-carb	Low-carb	Nuts, lactose-free, vegetarian	No	No
Usual cooking method	Instructions	Instructions	Instructions	Instructions	Read ahead & adjust (mix)	Mix	Mix
Preference	Instructions	Instructions	Without instructions	Without instructions	Loose instructions	Loose intructions	Instructions
Cooking company	With partner	Alone / with partner	With partner	With partner	Alone	With partner	With partner
Cooking enjoyment	Very much (5/5)	Very much (5/5)	Quite a bit (4/5)	Somewhat (3/5)	Restrictions: Somewhat (3/5) No restrictions: Very much (5/5)	Very much (5/5)	Very much (5/5)
Cooking style	Curious cook	Life learner / Balance seeker	Balance seeker / Curious cook	Balance seeker / Curious cook	Proud plater / Balance seeker	Curious cook	Curious cook / Proud plater

Table 3. Participant answers from the preliminary interview

Journey Maps

The user's emotions in relation to which task they are carrying out was extracted from the video footage and filled in note sheets (see appendix D) in order to plot on a journey map. The emotions were split into positive, neutral, and negative emotions to clearly distinguish the users emotional journey. Summarized quotes from the cooking experience are indicated below the emotions. The quotes are extracted from the video footage and summarized to provide an easy-to-understand overview of what the user was trying to convey. From these insights, pain points are assumed by the researcher along with initial solution ideas. Design opportunities or areas of improvement that are not associated with a pain point are also expressed in the journey map from the researchers interpretations.

The 1st participants journey map can be seen in figure 6. They cooked Chinese scallion pancakes in approximately 30 minutes. They expressed frustration with having to scroll up and down through the recipe on their mobile device in order to revisit the ingredients and their amounts. They experienced some moments of uncertainty regarding how much of the pancake mixture needed to be added to the pan and did not trust whether the instruction time estimates were accurate.

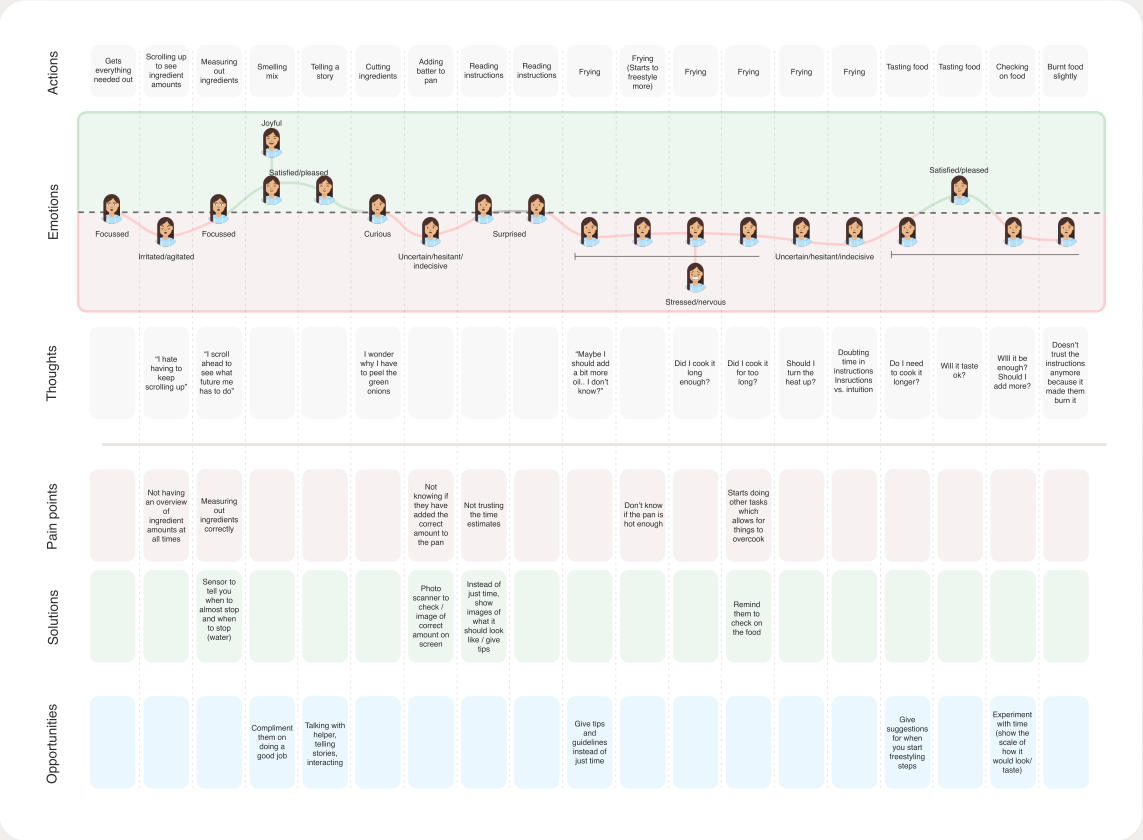


Figure 6. Journey map of participant 1

Participant 2 cooked a butternut squash risotto. It took them over 1 hour to cook it, including oven time. The user experienced a lot of uncertainty during the cooking experience and appeared to be nervous with the researcher's presence. They questioned their decisions and worried about the final result. The user described themself as having a Life Learner cooking style which is in line with the cooking behaviour observed.

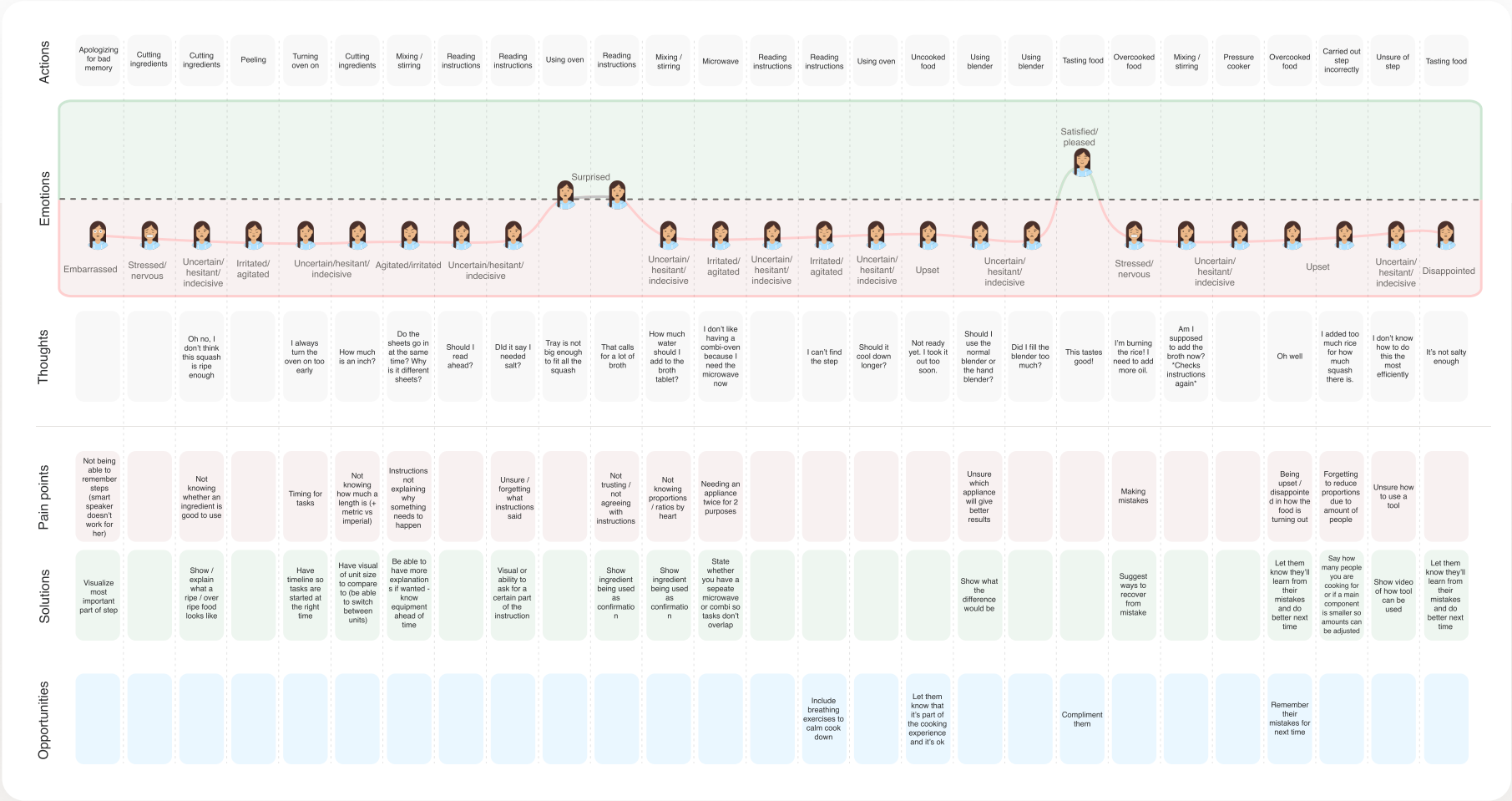


Figure 7. Journey map of participant 2

Participant 3 cooked a paella with chicken and shrimp in about 20 minutes. They rushed through the recipe with little emotion. They faced difficulties regarding keeping track of which tasks had already been completed and which tasks still needed to be completed.

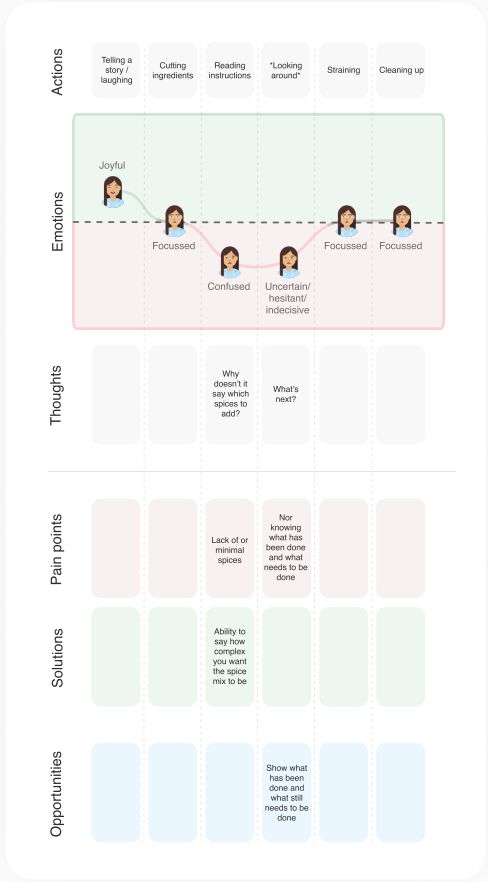


Figure 8. Journey map of participant 3

Participant 4 cooked fried miso eggplant with rice in 45 minutes. The first half of the cooking experience ran smoothly. However, the participant started getting stressed near the end when several tasks had to be completed at the same time in order for all components to be finished at desired times.

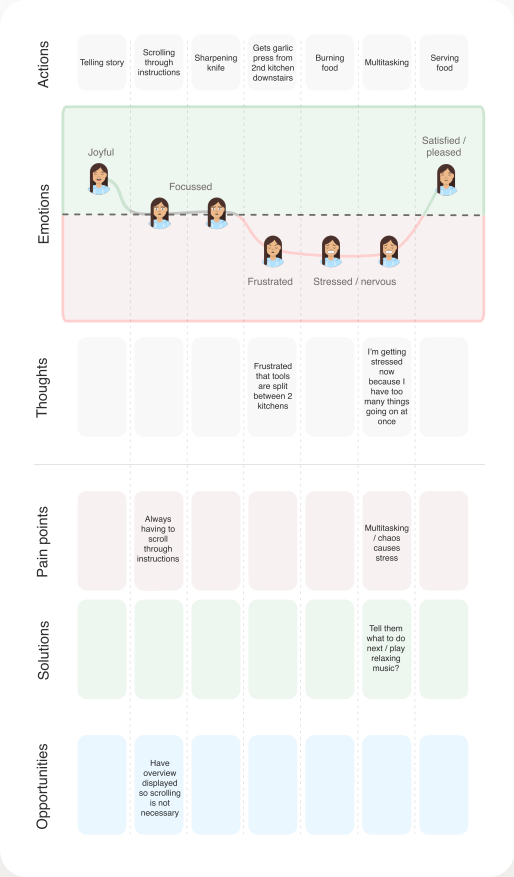


Figure 9. Journey map of participant 4

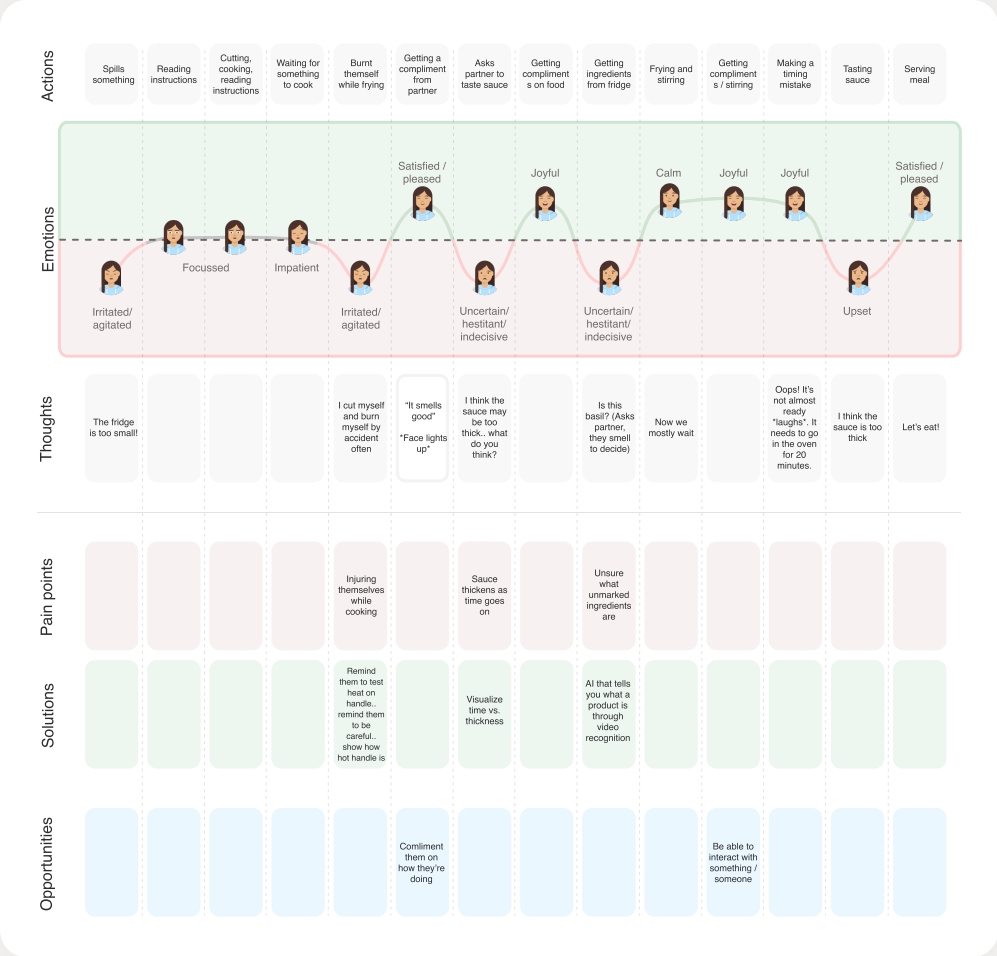


Figure 10. Journey map of participant 5

Participant 5 cooked an Italian baked trofie. It took them approximately 1 hour. They made a few mistakes during the process which irritated them, however, it was brushed off quite quickly. The cooking process seemed as though it was an enjoyable hobby for them.

Referring to Instructions

The number of times the user referred to their instructions was extracted from the video footage. The videos were watched at 10 times their original speed and the number of times the user looks at their device to check the instructions, was tallied. The amount of times that the users looked at the instructions can be seen in table 4.



Figure 11. Participant checking the instruction on their mobile device.

	Participant 1	Participant 2	Participants 3	Participant 4	Participants 5
Time spent cooking (minutes)	30	60	20	45	60
Checks instructions (times)	32	30	27	5	10

Table 4. Overview of how long it took for participants to cook the recipes and how often they referred to their devices that contained the instructions

Multitasking

The number of tasks the user switched their attention between at a given time, was recording on the note sheet during the sessions. The users switched their attention between 2 and 4activities at once (seen in table 5).

	Participant 1	Participant 2	Participants 3	Participant 4	Participants 5
Number of tasks at once	3	2	3	4	4
Tasks	Frying food Cleaning up dishes Making sauce	Cutting food Referring to instructions	Frying food Cleaning up dishes Cutting food	Tidying kitchen Making sauce Cutting food Stirring cooking rice	Whisking sauce Stirring other sauce on stove Telling stories Sauteing food

Table 5. Greatest number of multitasks at one given time, per participant

Coding

Thematic analysis techniques were used to generate themes from the context research.

The pain points, design opportunities, researcher notes, and summarized participant messages were then extracted from the journey maps to be closely reviewed and coded (see figure 12). The codes are inductive and derived from the researcher, meaning that the codes were generated from interpreting the data instead of from pre-existing codes (Braun & Clarke, 2006). This approach has been chosen as the research is explorative. The coding is used to group relating notes which can ultimately be used for clustering into larger categories. The participant that is associated with the note can be seen by their corresponding number in the top right corner.

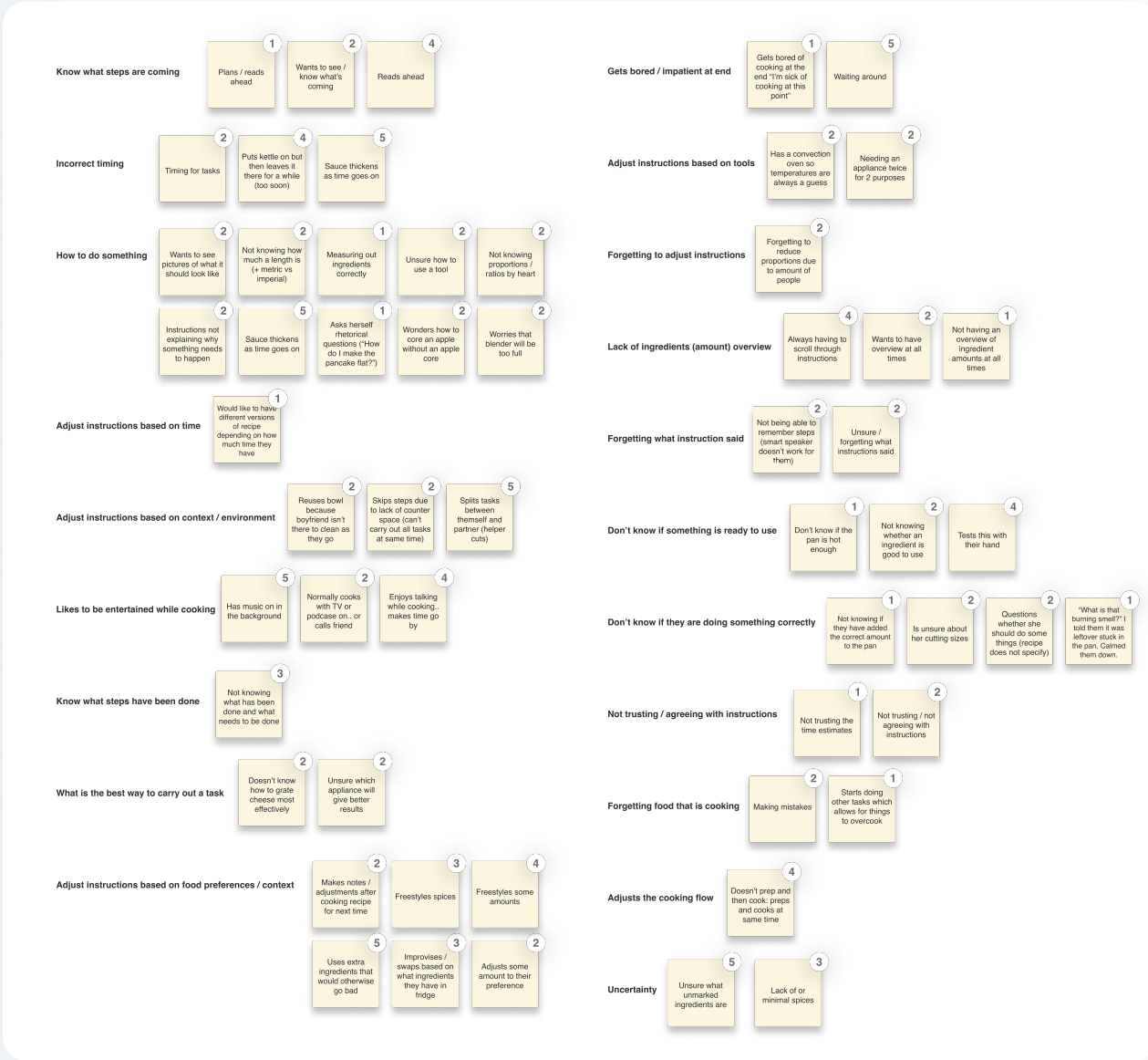


Figure 12. Coded information from journey maps

Clustering

Similarities between codes are identified in order to cluster the coded notes into the 7 categories: Lack of timeline overview/incorrect timing, uncertainty, lack of trust in instructions, getting bored/wanting to be entertained, forgetting instructions or ingredients (amounts), forgetting food that is cooking, and personalizing the instructions. Figure 13 shows the clusters of the coded notes. The related codes are shown next to the note groups. The corresponding participant number is still shown in the top right corner of the notes. The number of participants that associate with this cluster, can be seen next to the cluster title (e.g. 4/5). The accompanying emotions, defined in the journey maps, are next to the clusters.

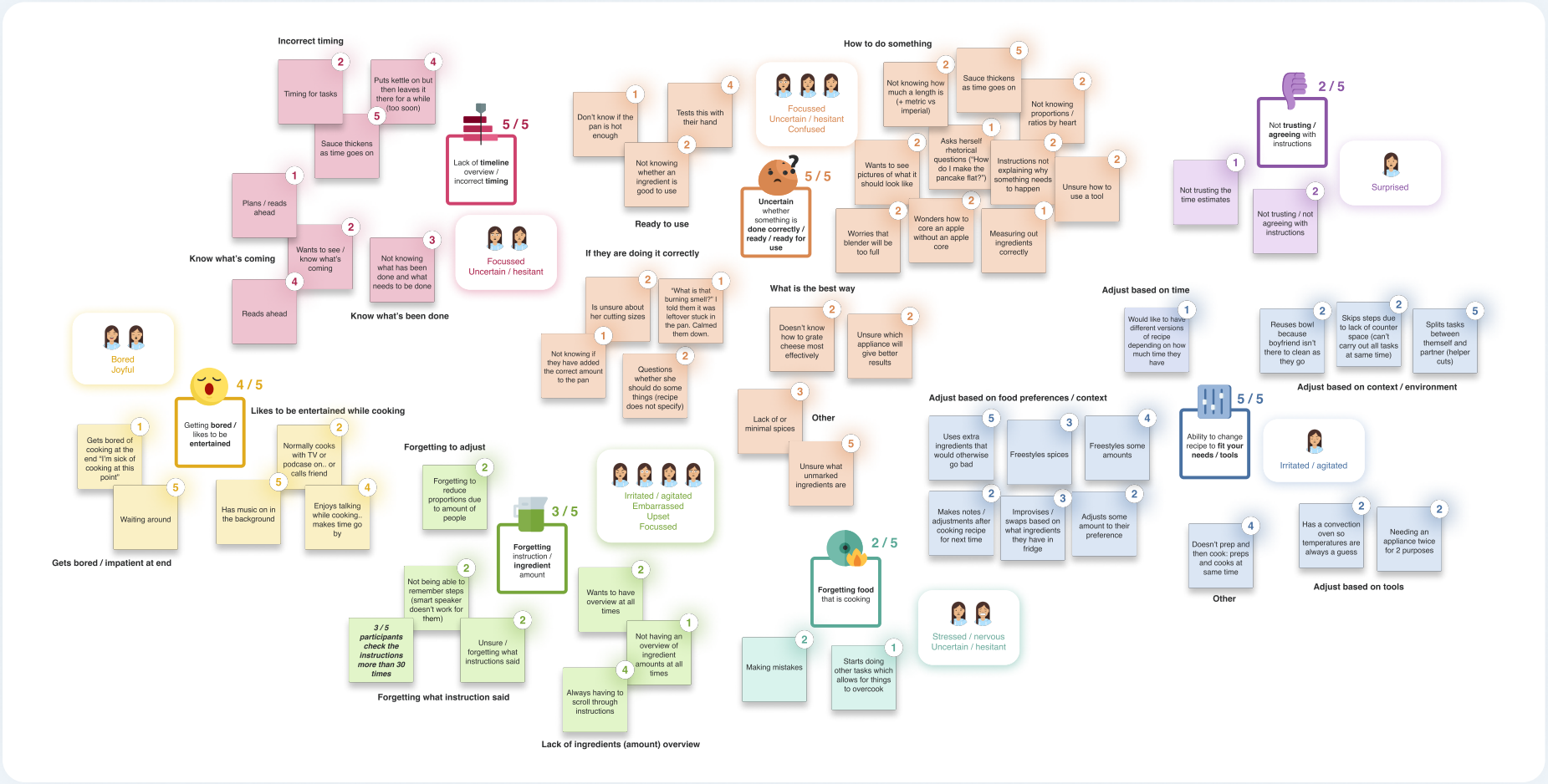


Figure 13. Clustering of coded notes

Closing Interview Answers

Summaries of the participants answers from the closing interview are shown in figure 14. They have been summarized from the quotes in the transcriptions and not their exact quotes. The information is shown this way in order to simplify the data and clearly communicate what the participants wanted to convey in order to interpret the data. Most of the users describe their cooking experience as quite usual. Participant 4 describes their experience as more chaotic than usual due to poor timing and external stimulus. Participant 5 stated that they felt more relaxed than usual, even despite the unusual extra waiting times for their chosen recipe due to it being the weekend. The summarized notes have first been organized under the interview question in the participant number order, as seen in figure 14, in order for the researcher to gain an overview of the answers.

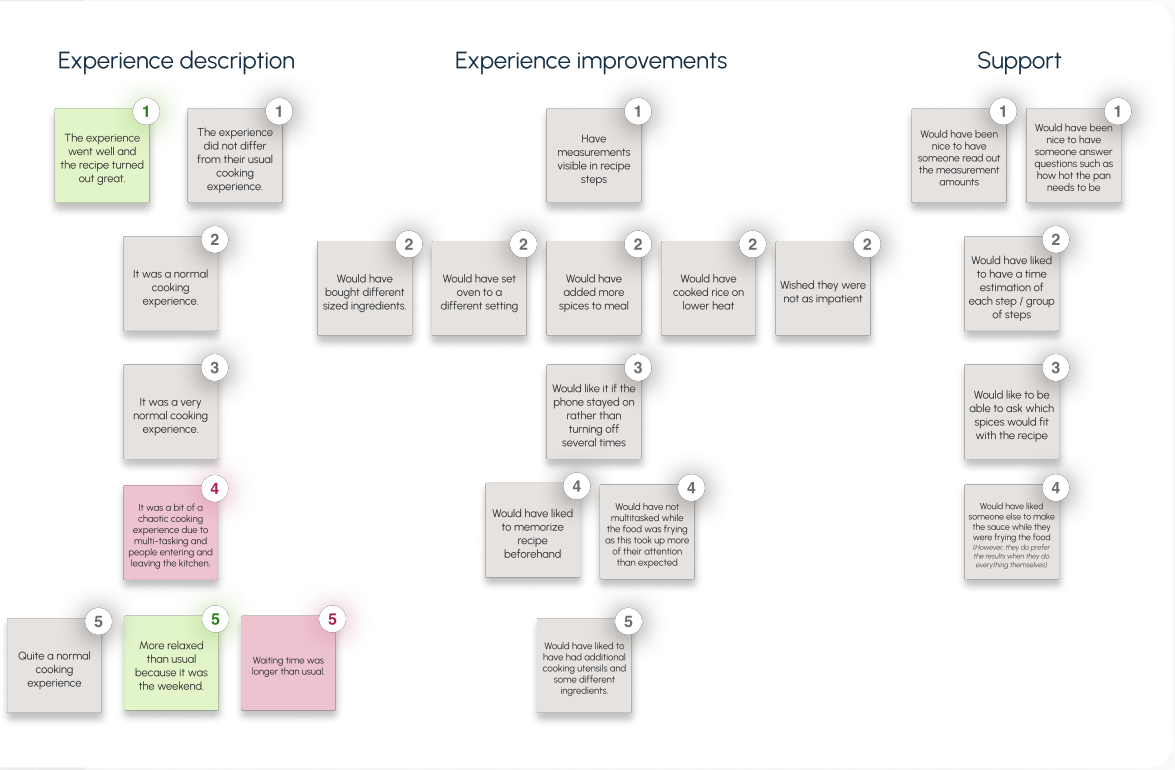


Figure 14. A mapped out visual of summaries of what the users said during the closing interviews. Green notes represent positive answers, red depict negative answers, and grey notes represent neutral answers. The number in the top right corner represents the users number (e.g. 1 equals participant 1).

Coding

The summarized closing interview answers are subsequently organized into groups associated with 1 of 8 codes in order to determine initial topics:

01 Positive cooking experience

02 Negative cooking experience

03 Normal cooking experience

04 Things the user would do differently

05 Desired changes with the recipe instructions

06 Desired changes with their devices

07 A helper to do tasks

08 A helper to answer questions

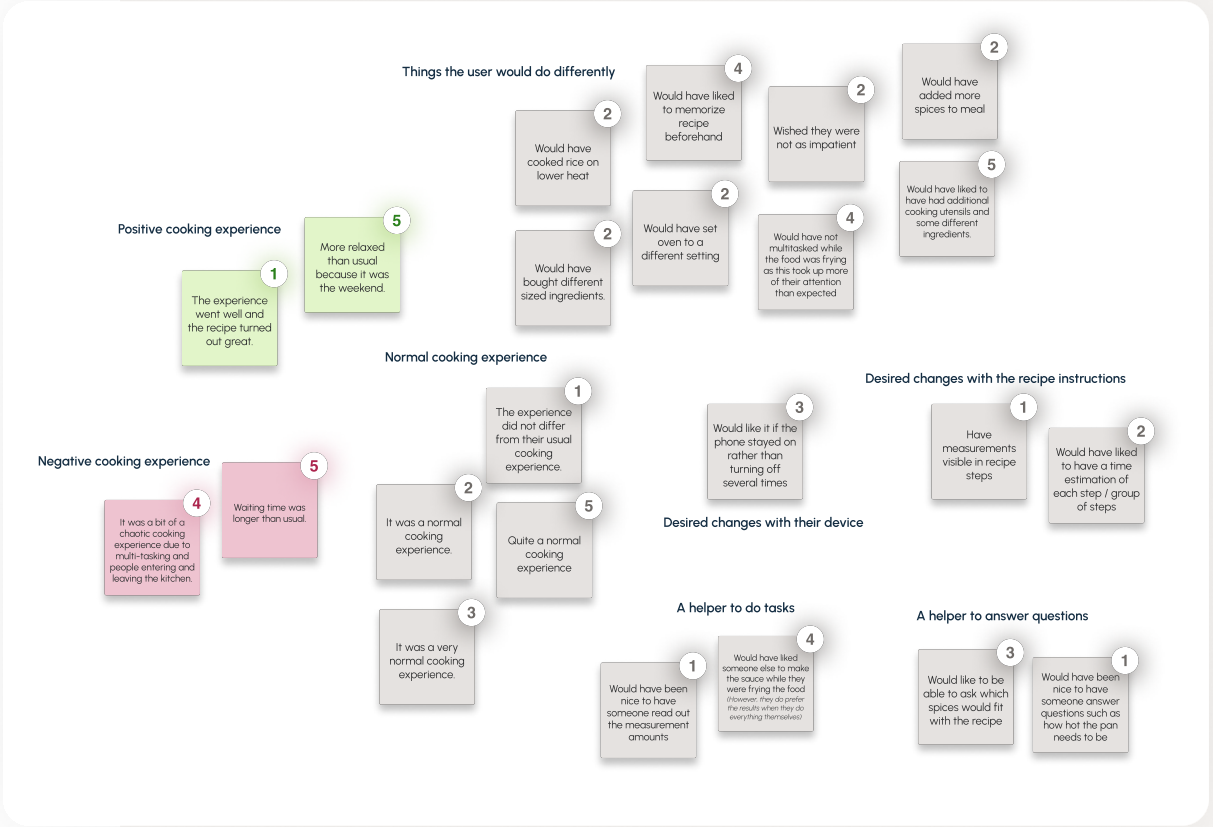


Figure 15. The answers, from the closing interview, clustered into categories based on similarities

Clustering

The codes (and their corresponding notes) are then further clustered into 4 themes:

01 Cooking experience reflection

02 Things the user would do differently

03 Aspects of the user to instruction-delivery interaction they want changed

04 Cooking support

The 'cooking experience reflection' simply explains which cooking experiences were accurate representations of their average cooking experience and which differ. 'Things the users would do differently' contain topics such as setting the oven to a different setting or buying different ingredients. "Aspects of the user to instruction-delivery interaction they want changed" refers to what the user would change about interactions with the device they use to receive the instructions or the app/website on that device. Lastly, the cooking support theme contains wishes of having a person or device in the kitchen to help with carrying out tasks or asking questions.

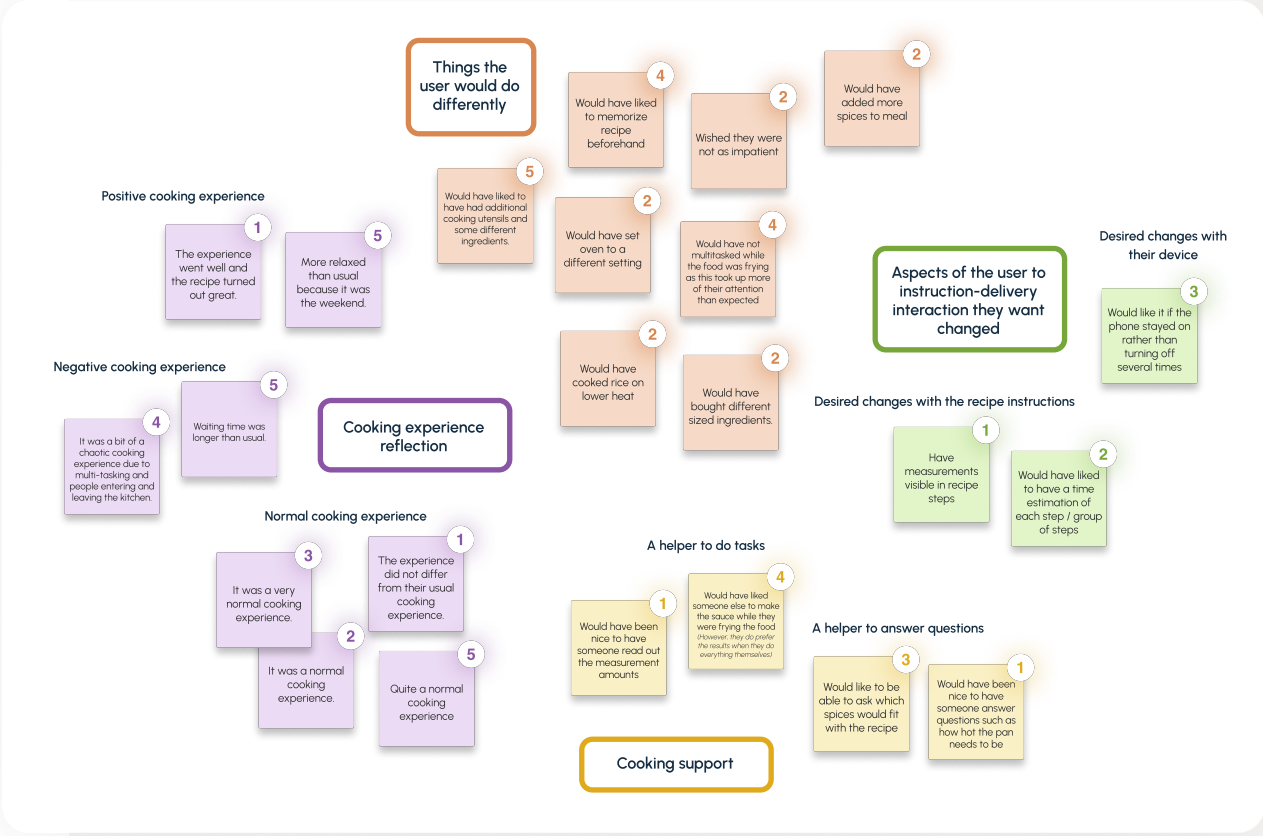


Figure 16. The answers, from the closing interview, clustered into categories based on similarities

Results and Insights

The analysis of the opening interview, observation session, and closing interview have resulted in the emergence of 4 identifiable themes. These themes convey how users experience cooking with instructions. The themes are the following:

01 Cognitive overload

02 Uncertainty

03 Changing recipe to fit needs

04 Getting bored or liking to be entertained

The participants that associate with the theme are portrayed with the following visualization:



This examples shows that participants 1, 4, and 5 associate with the theme whereas participants 2 and 3 do not.

01 Cognitive Overload 1 2 3 4 5

Focused Uncertain Stressed Embarrassed Irritated Upset

All 5 participants experienced cognitive overload while cooking, which led to forgetting instructions, ingredients & their amounts, burning food, and miscalculating timing & order of tasks. This caused emotions such as being focused, uncertain, stressed, embarrassed, irritated, and upset.

Participant 2 stated that they struggled with forgetting the instructions after they had read it and mentioned that cooking with smart speakers does not work for them for this reason. Participants 1, 2, and 4 expressed the need for having an overview of the ingredients and their amounts. Participants 1 and 4 stated that they strongly dislike having to scroll back and forth between the ingredient overview and the instructions on their mobile phones. The assumptions previously mentioned by Bradbury, Shell, & Knowles (2003), that using a cookbook can distract the user from the process of cooking, are validated by the context research due to how many times the participants referred to the instructions. Participants 1, 2, and 3 interrupted their task at hand to check the instructions on their devices approximately 30 times each (table 6).

Theme-relevant info extracted from coded note clusters

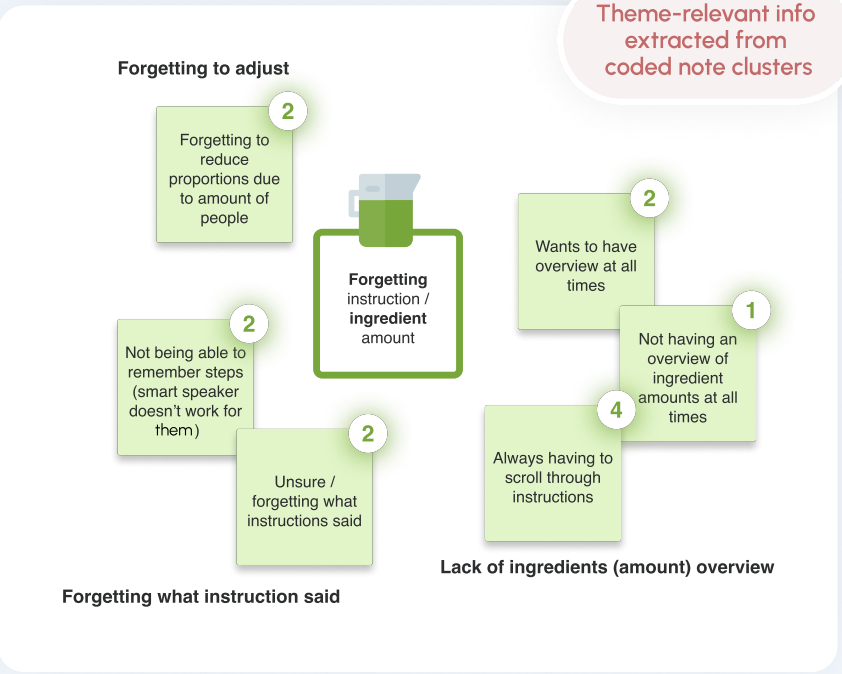


Figure 17. 'Forgetting instructions and ingredient amounts' cluster from the observation analysis

Theme-relevant info extracted from table 4

	Participant 1	Participant 2	Participants 3
Time spent cooking (minutes)	30	60	20
Checks instructions (times)	32	30	27

Table 6. Relevant information to theme from table 4

Theme-relevant info extracted from closing interview clusters

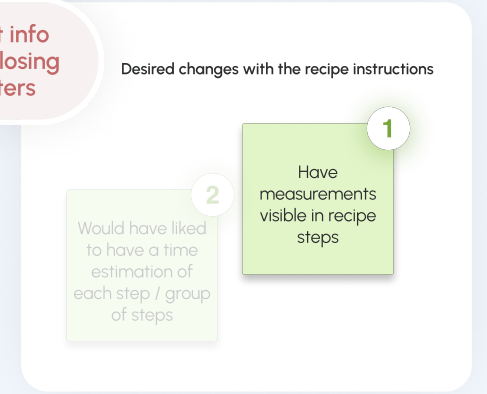


Figure 18. 'Desired changes with the recipe instructions' from the closing interview analysis

The users also experienced issues regarding determining when to carry out a task in order for that task to be completed at the desired time. Participant 2 stated that they would benefit from having a time estimation of each task in order to more efficiently plan out when they should start with each task. Participant 4 declared that they wish they had known to make the sauce first when the cooking experience was still calm, rather than later when multitasking made the experience chaotic. Participants also found it important to know which tasks needed to be completed before they arrived at that task. This is apparent from the fact that users read ahead before cooking a recipe or wished that they had read ahead, after the fact. Participant 3 expressed wanting to know which tasks had already been completed in addition to which tasks still needed to be completed. This is because they wanted to see which cooking items could be cleaned up, and expressed that this is especially useful if 2 people are cooking. These findings provide deeper insight into the finding of Buykx (2011).

The cognitive overload regarding the user having to switch their attention between multiple tasks also proved to be a problem in the kitchen, again confirming assumptions from Bradbury, Shell, & Knowles (2003) and Buykx (2011). The context research shed deeper insights into the problem by identifying emotions felt while multitasking as well as the issues that occur as a result of multitasking. Participants were visibly stressed while multitasking and mistakes, such as burning food, occurred with participants 1 and 2. To further validate this insight, participants 1 and 4 mentioned that they could have benefited from someone taking over some of their tasks when multitasking was occurring.

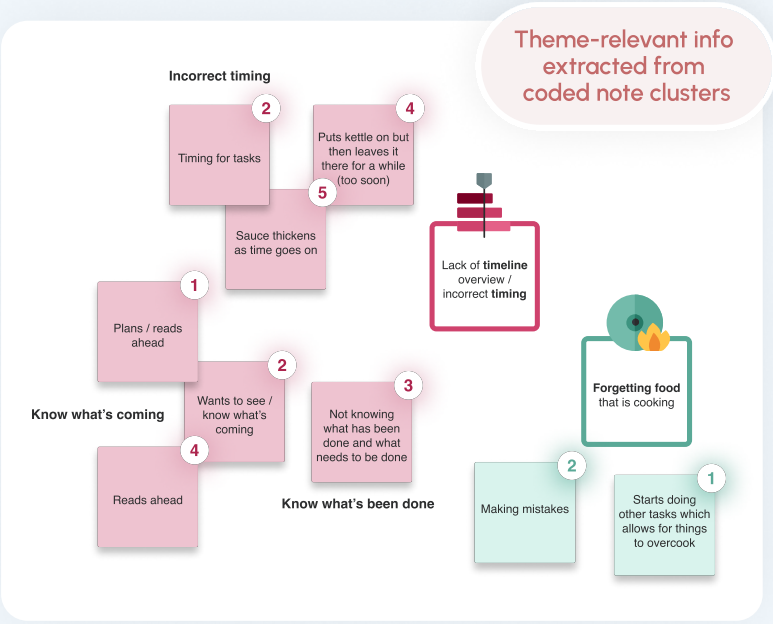


Figure 19. 'Lack of timeline overview & incorrect timing' and 'forgetting food that is cooking' clusters from the observation analysis

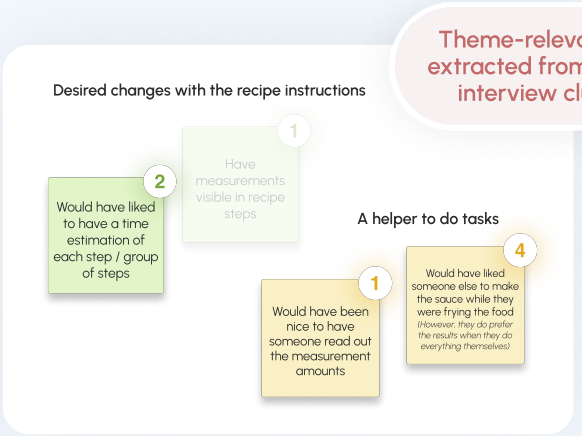


Figure 20. 'Desired changes with the recipe instructions' and 'a helper to do tasks' clusters from the closing interview analysis

Repeat of table 5

	Participant 1	Participant 2	Participants 3	Participant 4	Participants 5
Number of tasks at once	3	2	3	4	4
Tasks	Frying food Cleaning up dishes Making sauce	Cutting food Referring to instructions	Frying food Cleaning up dishes Cutting food	Tidying kitchen Making sauce Cutting food Stirring cooking rice	Whisking sauce Stirring other sauce on stove Telling stories Sauteing food

Table 7. Maximum number of tasks each participant switched their attention between at a given moment and what those tasks were, from the table 5.

02 Uncertainty 1 2 3 4 5

Focused Uncertain Confused Surprised

All 5 of the participants experienced at least one moment of uncertainty while cooking which led to doubting their choices, over-thinking, making incorrect decisions, and interrupting the cooking process by looking up questions on their mobile devices. Emotions such as being focused, uncertain, confused, and surprised were observed for this theme.

During the cooking process, participants 1 and 2 regularly asked rhetorical questions when they did not understand something. Participant 1 would then try an action to see what happened whereas participant 2 would dwell over what to do and whether or not they made the correct decision. Participants 3 and 4 also had questions and uncertainties during the process which they would solve by looking up answers on their mobile devices. Participant 5 would ask their questions to their partner. In short, uncertainties presented the most often out of all the problems while cooking and were solved by either trial-and-error or finding the answer from an external source.

Participants 1 and 2 questioned the instructions in the recipes while cooking. Both participants chose to disregard the mistrusted instruction and carry out the task in their own manner. Both cases resulted in mistakes that caused even more negative emotions.

Lastly, participants 1 and 3 confirmed the uncertainty observations made while they were cooking by stating that they would have benefited from having someone available to answer their questions during the process.

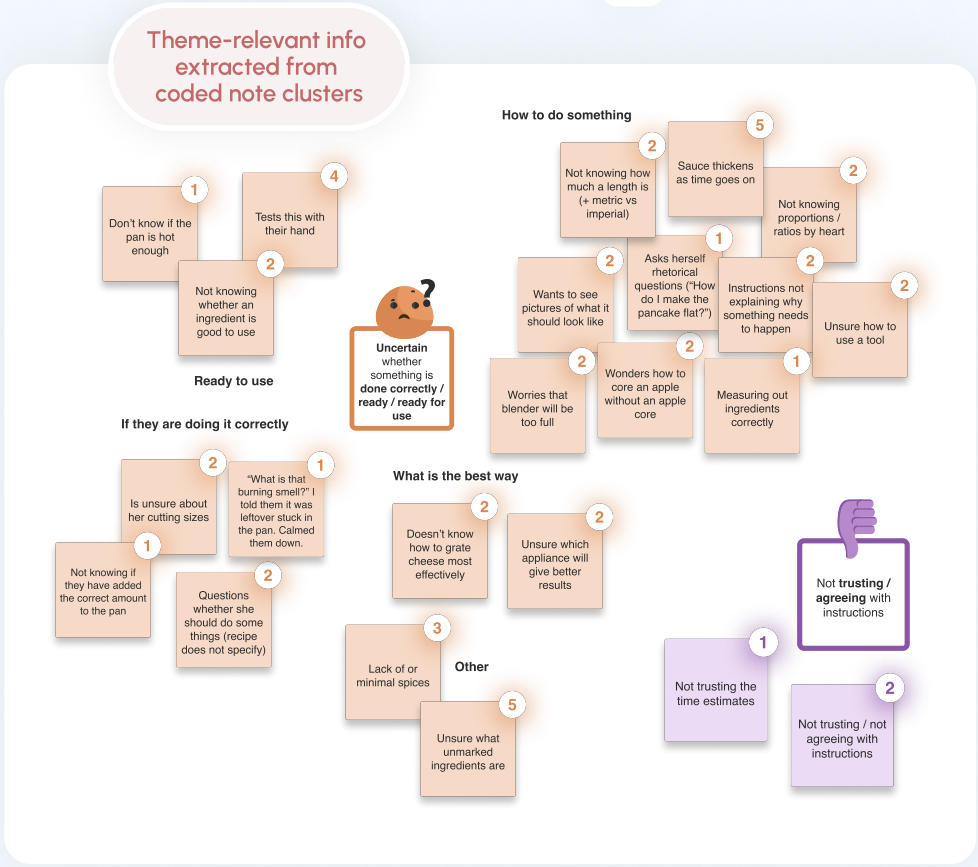


Figure 21. 'Uncertainty' and 'not trusting or agreeing with instructions' clusters from the observation analysis

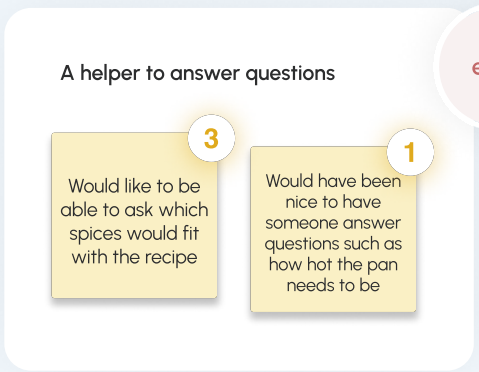


Figure 22. 'A helper to answer questions' cluster from closing interview analysis

03 Adjusting Recipe to Fit Needs 1 2 3 4 5

Irritated

All 5 participants either changed the recipe to fit their needs or wished there was a way to do so. Participant 1 expressed wanting to have different variations of the recipe that adjusted the length of time it would take to cook it. This would allow them to choose which version they would like to cook depending on how much time they have at hand. Participant 2 changed the order of the steps due to the lack of counter space. They did not have the space to cut and store all the produce at once, so they started cooking the vegetables they had cut before moving on to cutting the next. This adjustment led to some confusion regarding timing. Participant 2 also adjusted the oven temperature from the instructions due to having a convection oven as opposed to a conventional oven. Participant 3 did not have time to go to the grocery store the day of the cooking session, so they substituted some ingredients in the recipe for what they had in their fridge. Participant 4 stopped following the recipe when it came to making the sauce. They stated that they have made similar sauces before and prefer how they make it. Lastly, participant 5 added extra ingredients to the recipe that otherwise would have gone bad. These observations are further validated by the answers of participants 4 and 5 in the preliminary interview question, "How do you usual cook (with or without instructions)?". They both stated that they preferred cooking with a mixture of following the instructions and making personal adjustments.

Theme-relevant info extracted from coded note clusters

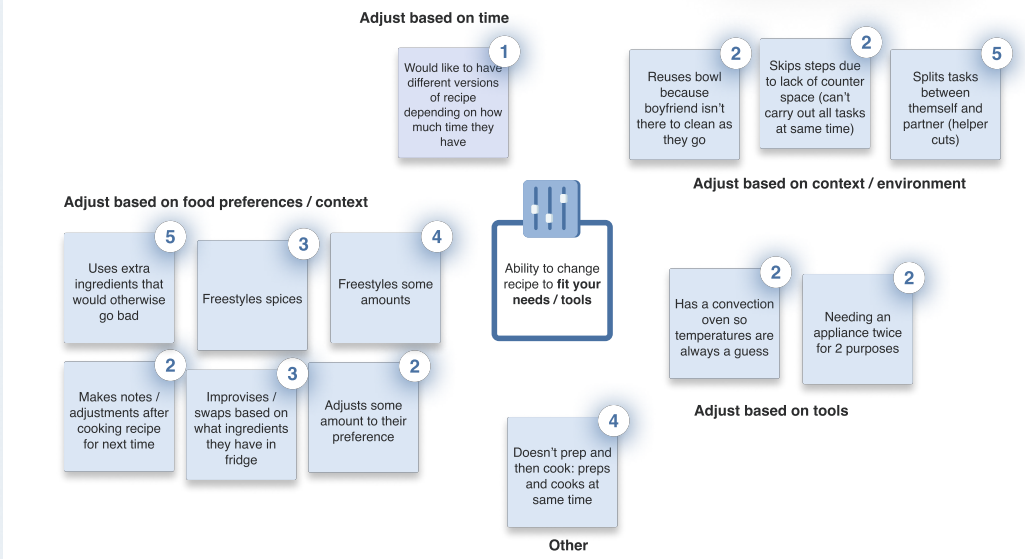


Figure 23. 'Ability to change recipe to fit needs or tools' cluster from the observation analysis

Theme-relevant info extracted from table 3

	Participant 4	Participants 5	
Usual cooking method	Read ahead & adjust (mix)	Mix	Mix

Table 8. 'How do you usual cook (with or without instructions)?' from the opening interview answer analysis

04 Getting Bored or Liking to be Entertained

Bored Joyful

Participants 2, 4, and 5 all expressed enjoying being entertained while cooking by either talking, listening to music or a podcast, or by watching TV. Participant 2 indicated that this motivates them to get chores done while participant 4 stated that it makes time go by faster for them.

Participants 1 and 2 communicated that they get impatient at the end of the cooking experience. In both cooking sessions, the participants completed tasks perfunctorily in order to save time which led to food burning in participant 1's case and under-cooked food in participants 2's case.

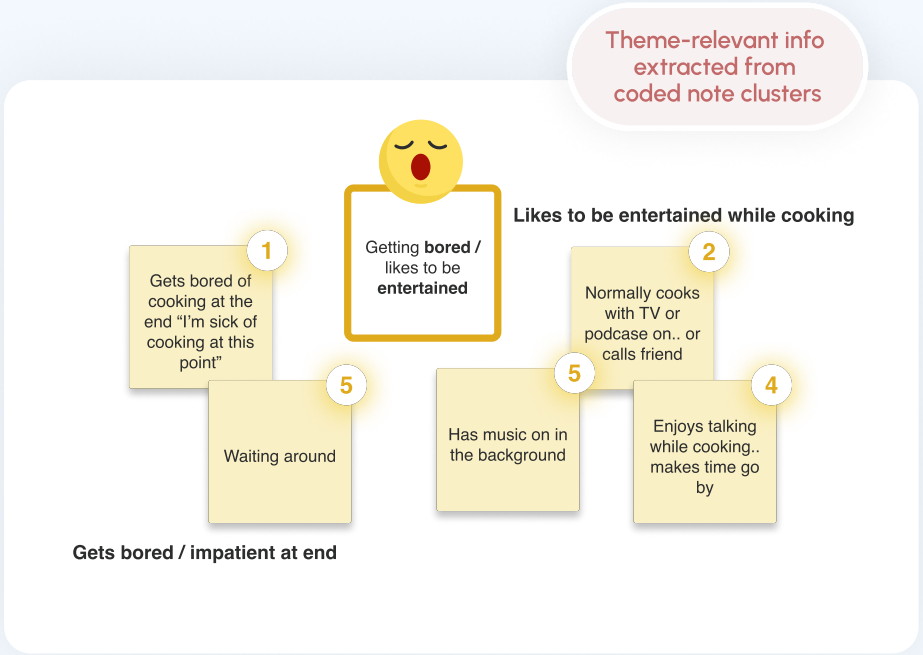


Figure 24. 'Getting bored or liking to be entertained' cluster from the observation analysis

> "Normally when I cook, I also watch TV... I either listen to podcasts or watch TV to force myself to do things (cook) that I don't feel like doing ... I normally have half my attention on what I'm doing."
>
> · Participant 2

> "I'm trying to smooth out the last bits of it to make it cook faster because, at this point, I'm just sick of waiting."
>
> · Participant 1

Main Insights & Assumptions

The following insights and assumptions have be derived from the aforementioned themes. These insights and assumptions will be used to define a design brief.

01 Users have a difficult time remembering instructions and ingredient amounts after they have read them
- This intensifies when the instructions are only delivered by voice

02 Having to touch the device that provides instructions breaks up the cooking flow

03 Participants find it difficult to determine when to start a task so that it is completed at the desired time

04 Participants desire having an overview of all the tasks

05 Participants find it difficult to keep an overview of the status of tasks as they are switching their attention between them

06 Participants are unsure whether or not they are doing a task correctly with just textual instructions

07 Participants nearly always adjust the recipe to some degree and follow instructions flexibly
- Participants are quite capable of swapping out ingredients or using alternative tools without much guidance
- Participants could benefit from guidance regarding how changing the order of the steps affects the timing of tasks

08 Multitasking should be limited to one 'active task' (where the users full attention is needed, such as cutting) and one 'semi-passive' task (where the user's attention is only needed sporadically, such as occasionally stirring something cooking on the stove) so that participants do not become overwhelmed. Many 'passive' tasks (where the user's attention is not needed at all, such as something baking in the oven) are assumed to be able to occur at the same time without issues.

09 Participants could benefit from a way to be entertained when feelings of boredom and impatience occur

Discussion

The following section discusses why the results are sufficient to continue to the next phase, aspects of the research that could have been done differently, and key observations and findings.

Participant Sample Size

Due to limited research into how users interact with recipe instructions and their environment while cooking, a total of 5 participant groups were chosen to be sufficient for exploratory research. Nielson (2000) found that 5 participants should uncover the key relevant insights, and that additional observations would merely show that these insights repeat themselves. For this project, 5 participants was chosen to be sufficient for progressing to the next stage: discovering design solutions. However, further research could validate the findings in this study with more confidence by observing more users. The context research has allowed for 4 themes to be identified in order to start generating design solutions, yet deeper research into a specific theme could be performed in order to understand the topic in more depth in order to generate more targeted designs. Due to the number of participants, some insights solely appeared once and therefore must be interpreted by the researcher in order to determine if these are applicable to other home-cooks. For example, participant 2 stated that they do not like cooking with smart speakers as they forget what was said shortly afterwards. It has therefore been assumed that a design solution should not only communicate verbally and instead should present the information with other methods as well. These findings provide sufficient insights and inspiration to begin the conceptualization phase.

Participant Variation

Similarly, there was also a lack of variety in the participant demographics. Effort was put into obtaining varying participants, yet the majority of the participants were female (5/7) and despite the fact that their ages ranged from 26-59, 5 out of 7 participants were aged from 26-30. This could imply that the participants were not an accurate representation of the average home-cooks. However, similar patterns were seen across participants regardless of their age and gender. This implies that the lack of variation may not be detrimental to the results. Additionally, this research was completed as an exploratory study to get an understanding of how people experience cooking while using instructions. Further research could expand on this research to reflect the population with more confidence. However, the recurring patterns of the explorative study provide adequate insights to specify initial design requirements.

Cooking Recipe

Furthermore, users could have been asked to cook the same recipe during the cooking sessions. The participants were asked to choose their own recipes in order to produce a cooking experience as similar to their normal experience as possible. However, it meant that recipes were difficult to compare to each other. Specifically how many times the user referred to their instructions. That being said, home-cooks with more experience chose more complicated recipes than those with less cooking experience. This produced cooking sessions where each of the participants were challenged, which revealed that home-cooks with varying cooking skills face similar challenges when following recipes that reflect their expertise.

Interview Questions

The participants could have been also been asked more questions during the interviews. For example, questions regarding their acceptance to and experiences with using various technologies while cooking would have provided an indication of how likely they would be to adopt an innovative

digital solution to cooking with instructions. An interesting question would be to ask if participants had used hands-free cooking instructions before, what were their experiences, and how likely would they be to invite an innovative recipe instruction product into their cooking routine? Additionally, it would have added value to ask participants to rate their average cooking experience during the observation session on a series of Likert scale questions. For example: 1.) How stressful was the cooking experience?, 2.) How intense was the cognitive load of keeping track of simultaneous tasks?, and 3.) How in control did you feel of the cooking process? These questions would have been useful in quantitatively comparing the experience of cooking with traditional instructions to that of a later proposed solution.

Representation of usual cooking experience

The cooking sessions aimed to be representative of the home-cooks usual routine. However, 2 users stated that the cooking experience did not depict a usual cooking experience for them; one was more stressful while the other was more relaxed. Nevertheless, the results are relevant as they provide insight into outlying cooking experiences that may also occur. In relation to this, the users were all being observed while cooking which may have resulted in a cooking experience that differed from their usual routines. This was apparent with participant 2, who seemed nervous by the researcher's presence, as well as participant 4 who was distracted by trying to converse with the researcher. Participant 1, 3, and 5 did not seem affected by being observed. All participants were asked to think aloud while cooking in order to obtain real-time insights. This is also not how they usually cook and may have distracted them from their cooking process. In connection, only participants 1 and 2 managed to think aloud during the entire cooking process. Other participants appeared to be embarrassed by speaking their thoughts and did not continue doing so for the duration of the session. This led to the researcher having to interpret the user's thought process instead of being told so. This, in turn, could have led to some misinterpretations. An alternative could have been to ask the users to record themselves cooking, without an observer present, and think aloud. This could have made the task less embarrassing as no external persons would be present during their cooking experience. However, the questions asked in the closing interview provided context to the researchers assumptions.

What users said versus what was observed

A combination of interviewing and observation was chosen as a research method in order to gain a deeper insight into their needs and confirm that what they say is actually what they do. Participant 2 identified themselves as a "Life Learner" which was apparent during the cooking session due to them worrying about their decisions and the outcome of the recipe. Participant 4 associated with the "Proud Plater" which was also evident as they served the dish with pride to the people eating. However, participant 2 also stated that they loved cooking which was difficult to notice while they were cooking. They appeared to be stressed and overwhelmed during the process. Afterwards, they stated that this was a normal cooking experience which generates doubt into whether they actually enjoy cooking. The same can be said for participant 5. They expressed that they loved cooking, that it was a hobby of theirs, and that they consider themselves an expert. However, during the experience they appeared to be stressed, disappointed with how some aspects turned out, they poorly timed a task, and even cut themselves during the process. There were unquestionably moments of joy and pride, specifically when other people tried their food, however, their mood was notably affected when tasks went wrong. Even more perplexingly, the participant described their cooking experience as being more relaxing than it normally is. Lastly,

participants 3 described themselves as "Curious Cooks" and "Balance Seekers", however, they appeared to be "Hungry Hustlers". They stated that they usually only cook for 30 minutes per day and during the session this was only 20 minutes. They lead busy lifestyles and part of the ingredients they use are already pre-cut. This knowledge lead to the assumption that they are instead mainly Hungry Hustlers.

Participants 1, 2, and 4 described themselves as proficient cooks. However, from observing them cook, participant 1 appeared to be competent whereas participant 4 seemed to be an expert. Although, this observation is only from one cooking session and should be interpreted skeptically. If the participants cooking skills are conveyed in this new manner, it becomes apparent that users with more experience cooked for longer (45 minutes to 1 hour) than cooks with less experience (20 to 30 minutes). This is also because they chose more complex recipes. In doing so they may have allowed the researcher to observe cooking experiences of participants that have all been challenged to a similar degree. All users experienced some level of uncertainty during the cooking experience, despite their cooking skill level. Timing mistakes were also observed across all skill levels. To summarize, expert home-cooks chose more difficult recipes which resulted in them being just as stressed and confused as inexperienced cooks. They clearly want to create more challenging dishes, but the instructions make it unnecessarily difficult for them. In addition, there appeared to be a cognitive dissonance with the fact that they say they enjoy cooking yet seemed frustrated with the process. That same dissonance can be observed with how they state they do not need assistance yet were observed making multiple mistakes. Clearly they want cooking to be an independent and enjoyable experience, but the current instructions are not fully enabling this. This could indicate that all cooking levels could benefit from reassurance and temporal support.

Assumed cooking problems versus results

Lastly, this project was initiated with the unproven assumption that users face high cognitive load while cooking, face issues regarding interrupting their cooking process to touch their devices, and have a need to personalize recipes. The 1st assumed problem, high cognitive load that is associated with having to switch between multiple tasks, has been proven to be an existent problem during the cooking experience. However, it is not only observed when switching attention between tasks, it also occurs when they do not have a clear overview of the cooking process as well as when they time tasks incorrectly (in some cases the high cognitive load leads to incorrect timing). In order to have an overview of the cooking process, participants had to try to remember the instructions and amounts or frequently scroll back and forth between the 2 on their mobile devices. The cognitive overload led to negative emotion, including stress, as well as making mistakes, such as burning food.

The second assumption was also proven: Participants find it cumbersome to have to touch their devices while cooking. This was observed as a problem as users had to frequently interact with their devices to absorb the instructions, thus, breaking up the workflow. Participants 1 and 2 specifically described this as a problem aloud. Participant 5 often avoided the issue by asking their partner to read off the instructions for them, thus making the instructions hands-free. This could suggest an advantage to using voice instructions and highlights the desire to have hands-free instructions.

Lastly, the assumption that not every step is useful to the user, or they may need more guidance was also proven. However, it did not appear to be a substantial problem for the cooks. If a step was not useful to them, they appeared to be able to easily disregard or adjust the step. However, if they did not understand the step and needed more assistance, it lead to frustration, confusion, and mistakes. Therefore, the instructions should be clear and informative to assure the home-cook that they are doing the task properly.

03 Current Solutions

The following section dives into the solutions that currently exist and aim to improve the instruction-based cooking experience. Multimedia solutions comprising both commercial products and academic prototypes are introduced. The aim of this section is to outline which solutions are available and which user problems, as described in the Context Research phase, these solutions solve. The gap that exists regarding the user problems and the solutions available to solve them will create the solution space for this project.

Introduction

Smart devices are becoming more apparent in home kitchens, such as smart fridges (Hippo, 2022). The technology often allow users to remotely control kitchen appliances that are connected with the Internet of Things (IoT). It allows users to improve the energy-efficiency and safety of their kitchens, yet enhancing the cooking experience by improving the interaction with recipe instructions has minimally changed in most households. A study with 2000 participants, done by Samsung KX (Samsung Newsroom U.K., 2020), found that 71% of home-cooks in the United Kingdom use digital recipe instructions. However, although these methods are digital, they are still linear cooking videos or listed recipe instruction that you would find in a cookbook. The following section explains several academic solutions to recipe instruction interactions, what their advantages are, as well as assumptions into why they have not been widely adopted. It also explains commercial solutions that are available to users are are more widely used. The findings serve as guidelines for how the design can be created to adapt to what solutions users are likely to embrace and where there is room to improve the current solutions available.

Academic Solutions

Smart Kitchen

Smart kitchens such as the Smart Kitchen (Hashimoto & Yamakata, 2008) aim to create a user-centric" system by allowing users to follow instructions while cooking as they would without instructions. The system observes the cooking experience non-intrusively and only suggests instructions when it senses that the user does not know what to do next. This approach promotes autonomy by allowing the users to follow the recipe steps in their own order. The kitchen uses optical and thermal cameras to track food ingredients and cooking actions in order for it to recognize when a step ends, so it can suggest a step that the user could carry out next. This is called Human Activity Recognition (HAR) technology. It is the act of Artificial Intelligence identifying and labeling human actions from gathered raw data (Gupta et al., 2022). It is currently used to solve several human-centered problems, especially in healthcare (Fu et al, 2020), such as monitoring daily activities of elderly people in order to notify relevant authorities if unusual activities occur (Serpush et al., 2022). However, it is also in smart kitchens.

Unfortunately, smart kitchens, like the Smart Kitchen, require users to purchase expensive hardware such as motion sensing devices, projectors, speakers, etc. in order for them to function.

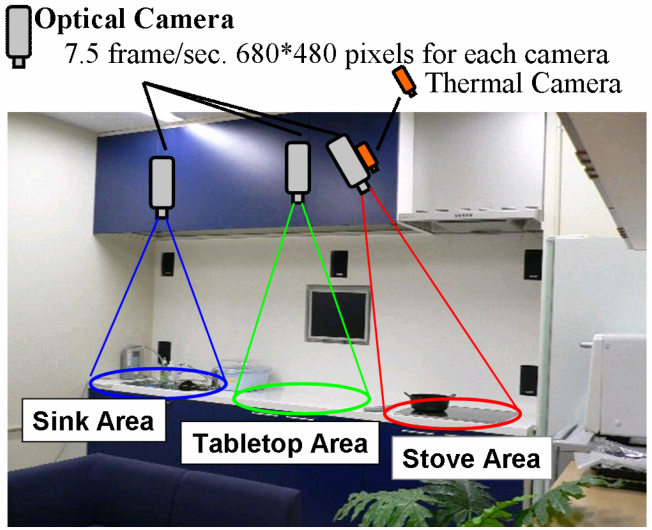


Figure 25. The Smart Kitchen environment (Hashimoto & Yamakata, 2008)



Figure 26. Proposed automation and monitoring system from the smart kitchen (Hassan et al., 2022)

A study by Kosch et al. (2019) provides valuable insights into how instructions could be more effectively delivered to users. They supply instructions by providing short videos, auditory instructions, and highlighting necessary items with projections. A Kinect v2 detects when a task was completed correctly so that it could provide the following instruction. This provides a possible method for the users to communicate to the device while they are cooking. The solution even aims to solve the 4th theme discovered in the context research, 'Getting Bored or Liking to be Entertained', by providing short cartoons during waiting times. They found that most of the participants enjoyed the video, auditory instructions, and highlighted items. However the research was completed with cognitively impaired participants in need of caretakers and therefore was designed to aid users in need of assistance while cooking, instead of autonomous cooks that this project focuses on. For example, most of the tenants could not read and therefore had to rely on verbal instructions.

The following phases of this project will explore how these insights can be applied to the average household cooking context by designing for their needs and utilizing more accessible technology that does not require the installation of additional hardware.



Figure 27. Study set-up for Kosch et al. (2019)



Figure 28. "Interactive step-by-step demo video controlled by natural hand gestures" from Majil, Yang, & Yang (2022)

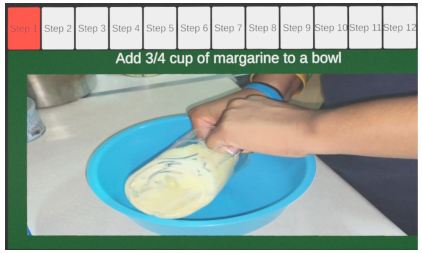


Figure 29. "Step-by-step video tutorial for the recipe for white cake. The video clip is semi-transparent on the foreground, so the user can see a little bit of the real scene (tiles on kitchen wall) beneath" from Majil, Yang, & Yang (2022)



Figure 30. Microsoft HoloLens 2 (https://www.microsoft.com/en-us/hololens/buy)

Augmented Reality Glasses

Other solutions are derived from using augmented reality (AR) glasses (such as Majil, Yang, & Yang, 2022 and Bonanni, Lee, & Selker, 2005). The prototype proposed by Majil, Yang, & Yang (2022) identifies food ingredients automatically simply by having the user look at it, allowing the device to suggest recipes based on what ingredients the user has available. Regarding following the recipe instructions, the user receives video instructions that are overlaid, in their field of vision, over their real cooking scene. The user can communicate to the device with a set of predefined hand gestures. This prevents the user from having to touch a device and allows the instructions to follow their movements. However, the users still have to communicate with their hands and wear a headpiece while cooking.

AR glasses do not require the user to install expensive hardware. However, it still requires the purchase of an AR headset which are still expensive. Some examples are the Google Glass Enterprise Edition 2 priced at approximately €1050 (Vr-expert, 2022) and the Microsoft HoloLens 2 priced at approximately €3850 (Microsoft, 2023). While the market for AR glasses is rising (ReportLinker, 2023), it is mainly adopted for commercial purposes as apposed to by consumers (Verified Market Research, 2021). This is perhaps due to the expensive costs. For these reasons, other solution spaces were explored for this project in order to create a more accessible design solution.

Eye Tracking & Voice Control

AREasyCooking (Iftene et al., 2020), and eyeCOOK (Bradbury, Shell, & Knowles, 2003) attempt to improve the current instruction-based cooking experience with the use of eye tracking and voice control. In contrast to smart kitchen and augmentation reality solutions, users do not have to install additional hardware in their kitchens with this solution direction. Although eyeCOOK used external eye tracking devices and microphones in 2003, eye tracking movements can be tracked nowadays using smartphone cameras. AREasyCooking uses Mobile Vision API software from Google (now part of ML Kit [https://developers.google.com/ml-kit]) to achieve this. Voice commands can be detected with smartphone microphones. As an example, AREasyCooking uses Google Assistant SDK (https://developers.google.com/assistant/sdk) to realize this. Regarding the solution efforts, AREasyCooking allows users to take images of their ingredients and uses a food model to identify the ingredients in order to suggest a recipe to the user. They also use eye tracking or voice control to allow users to control step-by-step video instructions. The user controls the video instructions using 4 voice commands: "Play" - starts the video, "Stop" - pauses the video, "Right" - skips forward 5-10 seconds (as predefined by the user), "Left" - goes backwards 5-10 seconds. The research found that the voice commands were not easily recognized when loud noises were present in the background, such as a running blender or gushing tap. This implies that users must wait for the loud sounds to finish before they can give their command, thus interrupting the cooking process. Alternatively, the user could control the video with 4 eye-commands: both eyes open means "Play", both eyes closed or not in camera view for a set number of seconds means "Stop", closing the right eye means "Right" while closing the left eye means "Left". The main issues observed for the eye tracking use case were the lack of facial detection abilities in dimly lit scenarios. Additionally, command confusion errors occur when the user blinks repeatedly. Lastly, the ability for the user to carry out the instructions while the video plays in background is impractical as the video pauses when the user looks away to focus on the task. The latter issue could be solved by finding a new eye command to pause the video. However, the user still can only interact with the device by being in an adequately lit room, in close range, and looking directly at the device, thus interrupting the cooking experience again. For these reasons, eye tracking does not seem to be a suitable approach for the user to communicate commands to the device either.

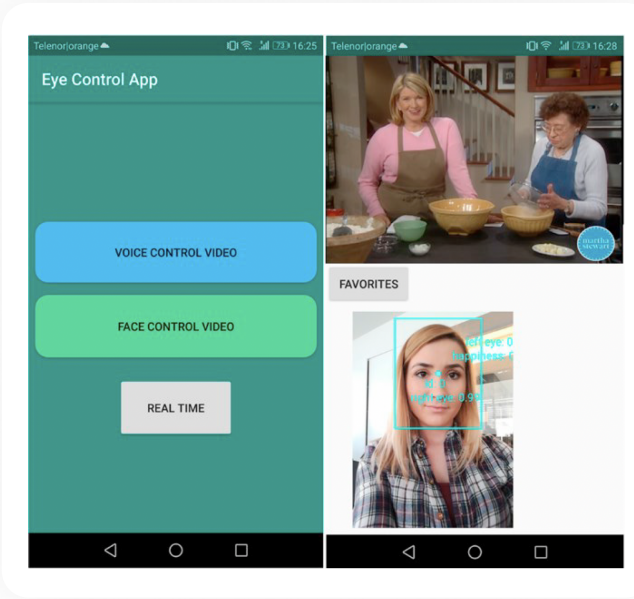


Figure 31. "Starting screen (left), testing mode (right)" (Iftene et al., 2020)

However, eyeCOOK uses eye tracking for a different purpose, namely, to switch between display modes. If the system detects that the user is looking at it, the page displays all the steps in the recipe as well as ingredients and their amounts on one page. When the user's eyes are not detected, the interface breaks into multiple screens to allow for the text size to increase. This allows the user to see the instructions better from a further distance. The issue of the eye tracking not working in dimly-lit conditions still applies yet the consequences are not as severe as in AREasyCooking. This is because the user can still see the instructions with eyeCOOK and does not use the eyes to communicate where they are in the process. The users can only not see the full overview. Hence, eye tracking could prove to be a useful method for the user to communicate less important commands to the device. However, it is not suitable for the main interaction method that this paper is looking for.



Figure 32. "eyeCOOK in Page Display Mode" (Bradbury, Shell, & Knowles, 2003)*: Users eyes are detected, therefore indicating they are in close range.*

Simultaneous Tasks

The Cooking Navi (Hamada et al., 2005) is a cooking navigation system that assists users in cooking several recipes simultaneously. The aim of product is to minimize the amount of time it takes to cook several recipes at once by completing tasks simultaneously instead of sequentially, as well as increase cooking accuracy and provide suitable instructions. It provides instructions with text, video, and audio. They explain that a recipe contains actions that occasionally have a logical order; for example, frying the eggs occurs after the eggs have been broken. Additionally, actions usually have to be combined or merged to finish the recipe. Their prototype displays this information to the user in a flow structure in the center of the interface (see figure 33). The structure shows which tasks need to occur in order, which do not, and when they need to be merged. The task that the user is currently working on is highlighted in orange. When the user has finished a task, they can click on the screen to get the instructions for the following task. Each task contains a textual description, dependency to the next task, video instructions, the tool needed to carry out the task (e.g. stove, cutting board, etc.), approximate duration for task to be completed, and whether the task can be completed in parallel to another task or not. The structure also groups tasks that are related to one ingredient.

The researchers carried out a preliminary experiment where users were able to cook with the concept. They found that novice to experienced cooks were all able to cook 2 recipes in parallel and enjoyed the cooking process more than usual. They discovered that cooking assistance using multimedia is an effective method to following instructions, meaning that the participants relied on all mediums. However, they state that their task scheduling algorithm does not allow users to act at will and should support the creativity of cooking more.

In conclusion, the Cooking Navi provides useful insights into how recipe instructions can be displayed, how recipes are structured, and how tasks can be timed in order for multiple dishes to be finished at the same time. This knowledge can be applied to temporal tasks for one recipe.

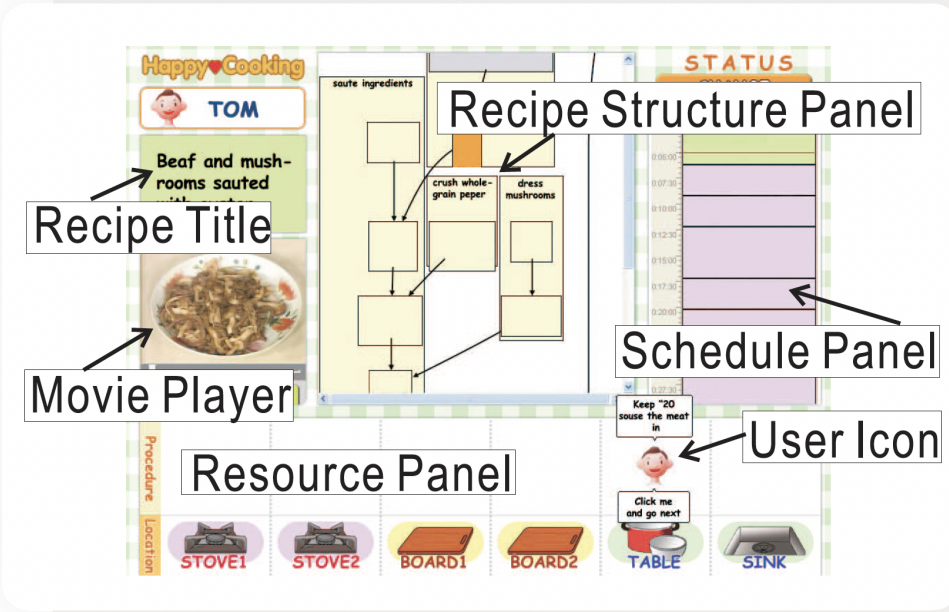


Figure 33. The Cooking Navi: Navigation window (Hamada et al., 2005)

Commercial Products

Commercially, some innovative cooking instruction products include Mealime (Mealime, 2019, *How to use cooking mode*), Voicipe (Voicipe, n.d.), and Google Assistant (Google Assistant, n.d.).

Mealime is a meal planning recipe product that has a hands-free cooking mode built into its mobile app. Users receive the instructions and ingredients textually and can move forwards one step at a time by hovering their hand over the screen. This interface solves the problem of having to touch your screen when your hands are dirty, however, you still have to interact using your hands which interrupts cooking tasks. Additionally, the solution does not contain a timer which one would need for time-related tasks such as baking potatoes in the oven.

Voicipe is also a mobile solution that allows for hands-free interaction yet with the use of voice commands. The product delivers the cooking instructions textually and with voice. The user is able to ask the device to read out a certain step by requesting that step number, therefore providing somewhat non-linear instructions. However, if a user carries out a step in a different order than laid out, the other steps do not react or adjust to this change, as the Smart Kitchen does. In contrast to the Smart Kitchen, it does show a preview description of all the tasks. Lastly, Voicipe does not contain a timer either, meaning users have to set one outside of the app.

Google also has a product for consumers to improve their cooking experience. With the Google Home or Nest speaker users can receive verbal instructions and communicate to the device verbally as well. With the Google Home or Nest display users can still communicate and receive instructions verbally but with the addition of an interface that shows the instructions textually as well as the ingredient with text and images. Google's solutions does allow users to set multiple timers during the cooking process. This means that the users can see timers for various tasks (see figure 37). Despite the many advantages of cooking with Google, it does not show the relationships between tasks or provide instructions in parallel. Instead, users still receive instructions linearly.

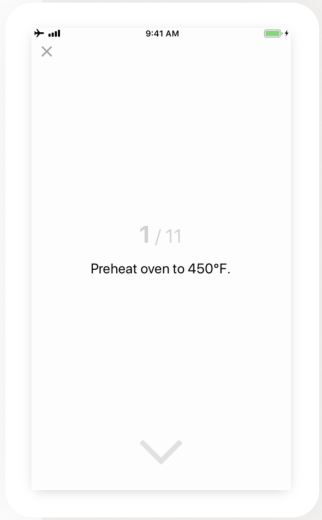


Figure 34. Cooking mode from Mealime (https://support.mealime.com/article/88-how-to-use-cooking-mode)

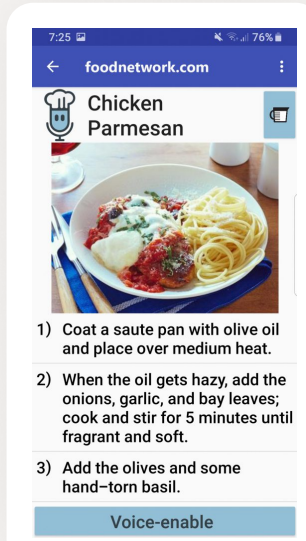


Figure 35. Hands-free cooking app with Voicipe (https://www.voicipe.com/how-to-use-voicipe/)

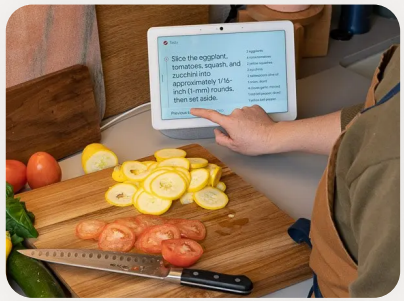


Figure 36. Cooking with Google Nest Hub Max. Image by Michael Murtaugh from https://www.nytimes.com/wirecutter/blog/cooking-with-google-nest-hub-max/



Figure 37. Multiple labeled timers with Google Nest Display (https://www.theguardian.com/technology/2018/oct/22/google-home-hub-review-smart-display-buy-google-assistant-digital-photo-frame)

Conclusion

In conclusion, there are several design solutions that strive to improve the instruction-based cooking experience. Table 9 provides an overview of all the current solutions discussed in this review. Relevant academic solutions include the Smart Kitchen, AREasyCooking, eyeCOOK, and the AR Interactive Cooking Guide. The Smart Kitchen and eyeCOOK require users to install hardware in their kitchens for the prototypes to work. Similarly, the AR Interactive Cooking guide requires users to have or purchase an all-in-one AR headset. AREasyCooking and eyeCOOK both utilize voice and/or eye control. Voice control functions the best in a quiet environment which may not always be the case in a cooking environment. This requires the user to wait until they can be properly heard. Eye tracking faces difficulties functioning properly in dimly lit conditions and forces the user to face the camera to interact with the device. For these reasons, eye tracking could be used for non-crucial communications but may not be the best solution for communicating important aspects, such as when to move to another step. Some examples of commercial solutions consisted of Mealime's cooking mode, Voicipe, and cooking with the Google Assistant. Mealime is a mobile app that enables interaction with the recipe instruction by using gestures. This removes the pain of operating a screen with dirty hands. However, they still need to use their hands to interact with the app, which disrupts the task at hand. Voicipe makes use of voice commands as well as verbal and textual instructions so that the user does not need to divert their attention away from their current task to communicate with the device. Google Home and Nest display use the same communication and instruction delivery methods as Voicipe but with the feature of multiple timers. None of the current solutions, with the exception of the Smart Kitchen, provide the user with non-linear instruction delivery; where the steps adjust if the user decides to change the order of the cooking steps. Some solutions allow the user to jump to a specific steps immediately rather than navigating through the steps one at a time. However, the other steps do not adjust to the new step order and instead stay linear. In this case, the steps are not connected to each other and instead exist independent of one another. This creates a rigid cooking flow which is not an accurate representation of how people actually cook (Hashimoto & Yamakata, 2008). This means users would have to jump from steps manually in the order of their choice instead of the device assisting them.

To summarize, there are several solutions that aim to improve the instruction-based cooking experience. However a solution that does not interrupt the cooking flow, allows the user the freedom to follow steps non-linearly, and includes timers/reminders does not exist yet. Therefore, this is the solution space that the Current Solutions phase maps out.

	Smart Kitchen	The Digital Cooking Coach	AR Interactive Cooking Guide	AREasyCooking	eyeCOOK	Cooking Navi	Mealime	Voicipe	Google	Google
Commercial product	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓
Academic prototype	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
Year of research	2008	2019	2022	2020	2016	2005				
Hardware	3 optical cameras, 1 thermal camera	2 speakers, 1 projector, 1 Kinect v2	All-in-one AR headset	Smart phone	LC Technologies eye tracker, wireless microphone, device to display interface	Pen touch panel or interface with foot switch	Smart phone (iOS & Android)	Smart phone (Android)	Google Home/Nest speaker	Google Home/Nest display
Hands-free option	✓	✓	✓	✓	✓	✓✗	✓	✓	✓	✓
Hands-free communication method	Human activity recognition	Human activity recognition	Hand gestures	Eye or voice control	Eye and voice control	Pen or foot switch	Hand gestures (Hover hand over screen to move to next step)	Verbal	Verbal	Verbal
Easily non-linear instruction delivery	✓✗	✗	—	✗	—	✗	✗	✓✗	✓✗	✓✗
	User can carry out any task they want and if they seem unsure, system recommends a step, user has no interface to see steps	Prototype provides next step when user is finished with previous step	Unclear User may be able to select steps with "pinch-gesture" (if steps are considered buttons)	Paper only discusses controlling video instructions with commands, "Play", "Stop", "Right" or "Left" (5-10 seconds)	Unclear	Current proposal guides users through linear steps	Can only move 1 step forward and backwards from where you are	Can ask to go to step #X, step text is written out, other steps do not adjust to change	Can ask to go to step #X, no interface preview, other steps do not adjust to change	Can ask to go to step #X, step text is written out, other steps do not adjust to change
Instructions	Verbal, video projections	Verbal, video projections	Textual, video projections	Textual, video	Verbal, textual	Verbal, textual, video	Textual	Verbal, textual	Verbal	Verbal, textual
Ingredient/tool list	—	—	—	—	Textual	Tools: images, textual	Textual	Verbal, textual	Verbal	Textual, images
Timer	✗	✗	✗	✗	✓	✓	✗	✗	✓	✓

Table 9. Overview of relevant solutions reviewed in the Current Solutions phase

04 Design Brief

This next section utilizes the findings from the Context Research and Current Solution phases in order to formulate a structured design direction and opportunity space. This will be used as the foundation for the Conceptualization phase where concept directions will be explored and developed. The design brief consists of a target user, design direction, design goal, and interaction vision.

Design Direction

A great deal of results, insights, and assumptions emerged from the Context Research. However, for the scope of this project, 1 of the 4 themes will be chosen as the design direction, namely, "Cognitive Overload". This theme has been selected as all 5 participants from the Context Research identify with it while cooking. Additionally, it produces a design space that is challenging and open to many design directions. It allows for an interesting design challenge into how to create a product that aids the user while minimally interrupting the work-flow. Designing for this theme has the potential to solve many problems as it contains several clusters from the Context Research phase. This theme is also associated with the most negative emotions, therefore creating a design solution has the potential to relieve the most negative emotions of all the themes. Furthermore, this theme allows for the exploration into ways to support non-linear and hands-free cooking instructions using a user interface design. A product that does so is yet to be designed, as outlined in the Current Solutions section.

Device

For the scope of this project, the solution will be designed for a tablet or laptop. This allows the screen space to adequately design for the theme. Future research can explore how the design could operate on a Smartphone.

Target User

The target user is determined to understand and define the users demographics, usage goals & challenge, and their habits in order to effectively design for their needs.

Demographics

Firstly, the user can be any gender. However, they need to cook with some regularity. The target user's age is not strictly defined. If the user can use an electronic device and cook, then they can interact with the product. However, the user should embrace digital tools in the kitchen which usually indicates a younger crowd. A study by Lando, A.M. (2018) found that 62% of American's aged 18-35 and use a personal electronic device, such as a tablet, while cooking. This is the age range that uses digital products in the kitchen the most frequently and is therefore the main target age of the user. They found that 47% of people aged 36-65 years old used electronic devices to follow recipe instructions. This is still a significant amount of people and should therefore also be considered while creating the design solution..

Challenges & Goals

The goal of the user is to reduce stress and cognitive load in the kitchen to enhance the instruction-based cooking experience. This is especially for new recipes where they have not had the time to remember the ingredients or have a grasp on temporal tasks. The cooking style, Curious Cook, aligns with this goal as they enjoy exploring new recipes and techniques. Additionally, the target user dislikes being required to interact with their cooking device with their hands and will therefore embrace a hands-free alternative. The intended user also faces challenges with timing tasks and wishes to find a solution to this. Lastly, the target user wants to use a recipe while still having the freedom to make adjustments. They see the advantage in having a device that adapts to their non-linear cooking behaviour.

Acceptance & Experience

The target user is open to receiving recipe instructions in a new and innovative way. They have experience with electronic devices and own a tablet or a laptop as this is the chosen device to display the product. The target user is comfortable using technology in the kitchen. The proposed design aims to be as user-friendly and understandable as possible, however, basic technological knowledge will be needed to use the product. As mentioned in the Current Solutions section, approximately 71% of home-cooks in the United Kingdom already use digital devices to follow recipe instructions (Samsung Newsroom U.K., 2020).

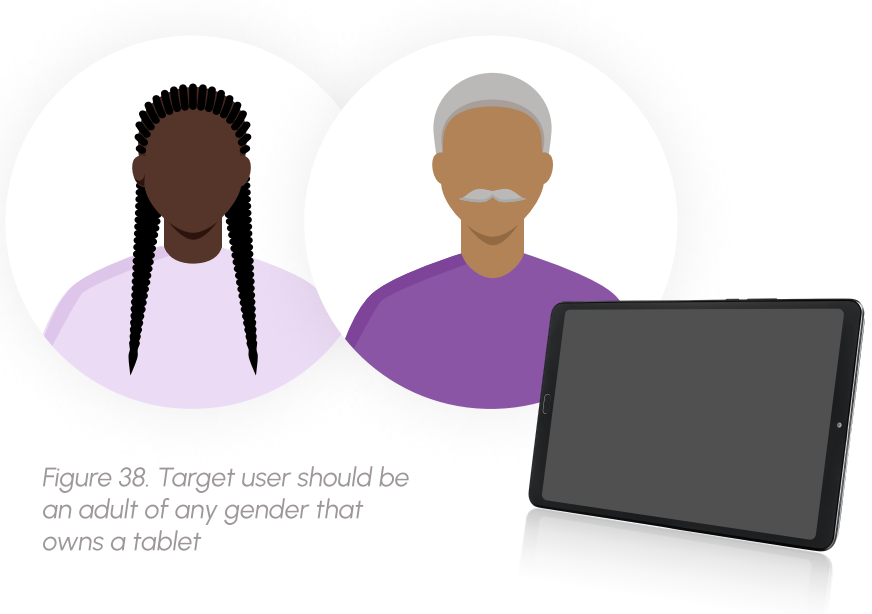


Figure 38. Target user should be an adult of any gender that owns a tablet

Design Goal

The design goal describes the intended effect of the prospective design solution.

The design goal is to create a product that allows home-cooks to use recipe instructions in a way that is hands-free, non-linear, informative, and that minimally interrupts the cooking flow along with reducing their cognitive load and associated negative emotions.

The design goal is to create a digital product that allows home-cooks, aged approximately 18-45, to improve their cooking experience with recipe instructions. The user should be able to interact with the product hands-free, as to minimally interrupt the cooking flow. They should be able to cook in a non-linear manner, as they might without cooking instructions. This means that it aids them in multitasking and adapts the instructions to the changes they may make regarding the order of tasks. The product should be informative, meaning it uses multiple mediums to display as much useful information as possible. In addition, the product should be as seamless as possible. The way the user and the product communicate with each other should also disrupt the cooking flow as minimally as possible. Lastly, the product should take over the task of managing simultaneous tasks that the user would otherwise have to monitor. The user should feel as thought the product is taking care of them. This, in turn, should reduce a great deal of the cognitive overload they feel and thus the negative emotions that are associated with it.

Interaction Vision

The interaction vision depicts how the user should experience interacting with the prospective design solution. It describes how the design should tackle the design goal.



Figure 39. Interaction vision of Grandmother guiding grandchild through recipe

The interaction vision if for home-cooks to feel as though their Grandmother is teaching them a new recipe. Imagine you are 12 years old and standing in your Grandmother's kitchen. She has decided to teach you her favourite recipe. You have never made it before and have limited cooking experience. She is standing next to you and calmly lets you know that she will guide you through the whole experience and tell you exactly when you need to do a task. You do not need to worry about the step order, timing, or task switching, but you do need to do everything on your own, so you can really learn. You are able to make suggestions to your Grandmother's instructions, and she accepts them with open arms, adjusting the rest of the steps for you. Furthermore, you are in a safe environment and trust your Grandmother's wisdom and ability to teach you in a fun and patient way. You are worry-free and eager to get cooking!

This interaction vision is appropriate as the Grandmother takes over the cognitive load from the grandchild; they do not need to worry about anything except cooking yet still have the freedom to make changes. The user feels comfortable and is in control of their actions while still having the comfort of knowing they are doing the right thing. The Grandmother provides the instructions and therefore the grandchild communicates with the instructions hands-free. The instructions can be delivered non-linearly. If the grandchild skips a step, the Grandmother can adapt to the changes.

05 Conceptualization

The conceptualization phase uses the guidelines from the design brief to develop concepts. The phase consists of 6 steps. First, available technology is explored to understand what is available to incorporate in the concepts. This is followed by defining the types of interactions that will occur while using the product in order to outline where design decisions need to be made. This is followed by an ideation phase where ways that the prototype can interact with the user regarding these interaction types are explored. Next, these interaction types and their potential communication methods are mapped out on a journey to display what interactions can occur at every critical moment in the cooking process. Lastly, 2 contrasting prototypes, that contain the aforementioned interaction methods, are developed in order to be tested in the interaction moments.

Artificial Intelligence

For the product to be hands-free, technology that allows the user to communicate with the product and vice versa without touching the device is needed. Additionally, the intended product should assume undesirable tasks that users would usually have to manage themselves, such as timing tasks. For these reasons, Artificial Intelligence (AI) technologies have been explored to determine which are relevant to this project and where they can be applied.

Types of AI

There are currently 5 main types of Artificial Intelligence (Bekker, 2019):

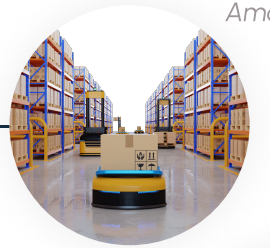
01 Analytical AI

02 Functional AI

03 Interactive AI

04 Text AI

05 Visual AI



Amazon robots



Augmented reality

Analytical AI refers to AI that makes recommendation to the user. Analytical AI uses machine learning to scan data, find patterns, and make predictions based on this information (Marx, n.d.). For example, analytical AI can predict the correct answers of customers questions that are asked on digital channels. Functional AI learns in the same way as analytical AI, however, instead of providing recommendations, it takes action itself. An application of functional AI is in the context of the Internet of Things (IoT) (Bekker, 2019). IoT has many definitions in different fields. In the context of smart technology, IoT could be described as smart products that are connected and can communicate with each other (Wortmann & Flüchter, 2015). Functional AI could be part of the IoT cloud and "spot a machine-breakdown pattern in the sensor data received from a certain machine, and trigger a command to turn this machine off" (Bekker, 2019). Another example of functional AI are robots that are able to carry out tasks on their own.

Interactive AI interprets text or speech from users to provide a response. Examples of Interactive AI could be chatbots or Smart Speakers (Bekker, 2019) such as Amazon's Alexa.

Text AI is used for translating, speech-to-text conversion, and more (Bekker, 2019). Lastly, visual AI "can identify, recognize, classify and sort objects or convert images and videos into insights", for example, facial recognition or augmented reality (Bekker, 2019).

Relevant AI

A few types of technologies have been ruled out from the Current Solutions research such as eye tracking technology for crucial communications and hand-gestures, due to the users having to interrupt their current task. A type of AI that could be used for hands-fee user-to-product communication that has not been ruled out is speech assistance, a form of interactive AI. The Context Research and Current Solutions review indicated that speech assistance could be an applicable method for communication as the user does not have to halt their current task to communicate. However, the research also indicated that speech assistance alone may not be ideal as the user may forget what the assistant said and have to frequently ask the device to repeat itself. For this reason, speech assistance should be used in combination with a user interface. A final drawback of speech assistance is that the environment needs to be relatively quiet for it to work properly which may not always be ideal. All aspects considering, speech assistance proves to be a communication method that is viable enough to explore as it exists in the device that users currently use in the kitchen and allows the interactions to be hands-free. Another plausible user-to-product communication method is video recognition. Video recognition technology, a form visual AI, can be used to recognize human activities. Video recognition AI also allows for the user to communicate with the user hands-free as the device recognizes what task the user is carrying out and adapts accordingly.

Furthermore, to create a hands-free and non-linear interaction, the AI also needs to know several aspects in relation to the cooking process. What the AI needs to know and how it could know this are outlined in table 10. This includes the communication methods as outlined on the previous page. Firstly, the AI needs to know all the steps in the recipe in order to present them to the user. The technology also needs to know approximately how long each of these tasks will take in order to convey this information to the user. This information can be found in the Swapmeals database. Next, the AI needs to know which tasks are dependent on each other and which can be carried out at any time (no dependency). This is so that the product knows which tasks the user can do whenever they please and which tasks need to be completed at a certain moment. The AI could know which tasks are dependent and which are not by providing it rules manually (e.g. "peel" always comes before "cut"). Additionally, the technology needs to know which ingredients are in the recipe, how much is needed, and whether the ingredient amount is split between steps. This can easily be found in the Swapmeals database as well as other recipe platforms. The AI also needs to know which tasks the user is currently doing, which tasks have already been completed, and which tasks still need to be done. This can be communicated through voice communication or via video recognition, as mentioned previously.

	What AI Needs to Know	How
Upfront information	All steps in recipe	Swapmeals database
	Approx. how long steps take	Swapmeals database
	Dependent & independent tasks	Information provided
	All ingredients & how much	Swapmeals database
	If ingredient is split between steps	Swapmeals database
Process communication	Which task user wants to do next	Verbally or video recognition
	What is currently being done	Verbally or video recognition
	What has been completed	Verbally or video recognition
	What still needs to be done	Process of elimination

Table 10. What the artificial intelligence needs to know and how it can know this to work efficiently in a product.

Exploration

What the Product Should Show	How	
	Visual	*Textual or numerical*
All steps in recipe	Timeline or list with images	Timeline or list with words
Approx. how long steps take	Size of step component	Written out
Dependent vs. independent tasks	Shown based on which level they exist on in timeline or connecting lines	--
All ingredients & how much	Images	Written out
If ingredient is split between steps	Ingredient image split into parts	Written in instructions
Which task user could do next	Images or videos of tasks	Textual explanations of tasks
What is currently being done	Images or videos instructions & colours/outlines	Textual instructions
What has been completed	Colours/outlines and icons	Words such as "Done"
What still needs to be done	Colours/outlines	Words such as "To Do"
Passive vs active tasks	Colours/outlines/fills	Written out

Table 11. What the artificial intelligence needs to know and how it can know this to work efficiently in a product.

As outlined in the design goal, the instructions that the user receives have to be informative in addition to being hands-free. This means that the user should have a detailed overview of the instructions as often as possible. The following section explores how this information can be portrayed to the users. This has been explored regarding both visual and textual/numerical representations. Visual representations were explored to provide the users more experiential interactions whereas textual & numerical representations were explored to provide the users more familiar and comfortable interactions. The table to the left illustrates all the mediums that have been explored.

Exploration Examples

The following sections provide visual examples and deeper explanations of the informative methods displayed in table 11. Extra explorations can be found in Appendix E.

Steps & their Lengths and Dependent/Independent & Passive/Active Tasks

The following page portrays examples of how all the steps in the recipe could be displayed. The explored methods are a timeline or a list with either images or text. Within these timelines and lists, the user can see how long each step will take. In figure 40, this is shown by where the task component lines up with the numerical scale above. If the beginning of component lines up with 6:00 and ends at 8:00 then it should take approximately 2 minutes to complete. In figures 41, 42, and 43 this is shown simply by writing out the time it takes (e.g. "2 minutes").

The examples also show dependent and independent tasks either by how they are placed in the timeline or connecting lines in the list. In regard to the timeline, if the task can not be completed until another task is finished, it appears next to the task before it. For example, the potatoes should not be cut before they have been peeled so "Cut the potatoes" appears to the right of "Peel the potatoes" (seen in figure 40). If tasks are not dependent on other task then they appear stacked vertically until a task has been selected. In figure 40, at the beginning of the cooking process they could have decided to start by peeling the potatoes, slicing the spring onions, slicing chives, or by slicing the parsley. They decided to start with the potatoes and the timeline adjusted to display the tasks they needed to completed before another decision moment occurs. In the list version, dependent and independent tasks are shown with lines. Figures 42 and 43 use a connecting line to show that frying the mushrooms can not be done until the user cuts the mushrooms. It also shows that while the user is cutting mushrooms, they should be heating oil on the stove. This is displayed with a dotted line. Heating the pan and heating oil are also shown as dependent tasks with a connecting line.

Lastly, passive and active tasks are shown with colour fills, outlines, drop-shadows, and/or text. As a reminder, an active task means that the user has to have their full attention on the task at all times (e.g. cutting an ingredient), whereas a passive task means that it can occur in the background (e.g. a dish baking in the oven). In figures 40, 41, and 43 active tasks are shown with a black border and passive tasks have a (partially) grey colour fill. Some tasks are passive and yet require moments of activity, such as stirring an ingredient that is frying on the stove. In figure 40 and 42, this is shown with a black circle. In figures 41 and 43, there is no representation of this information.

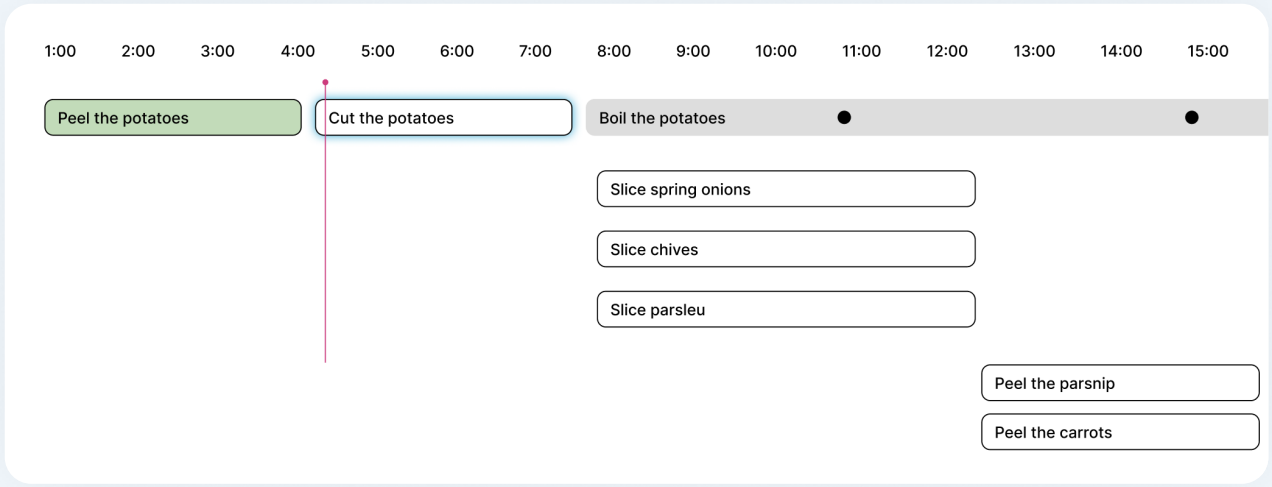


Figure 40. Textual timeline of tasks



Figure 41. Visual list of tasks

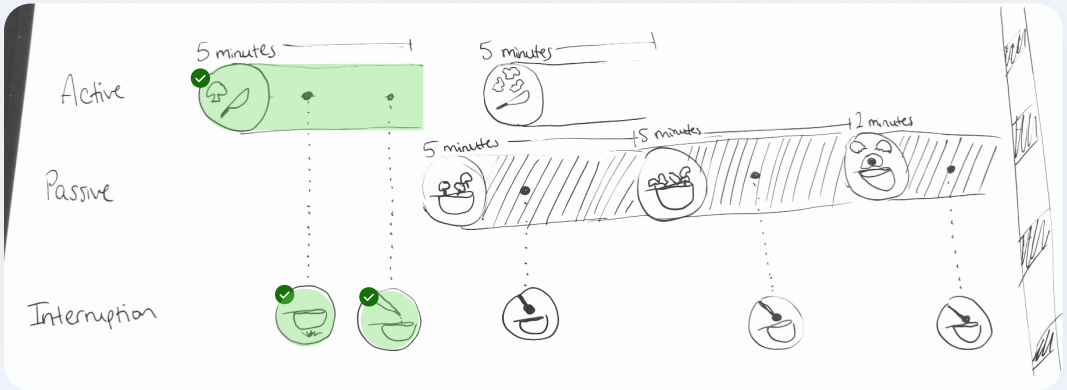


Figure 42. Visual timeline of tasks

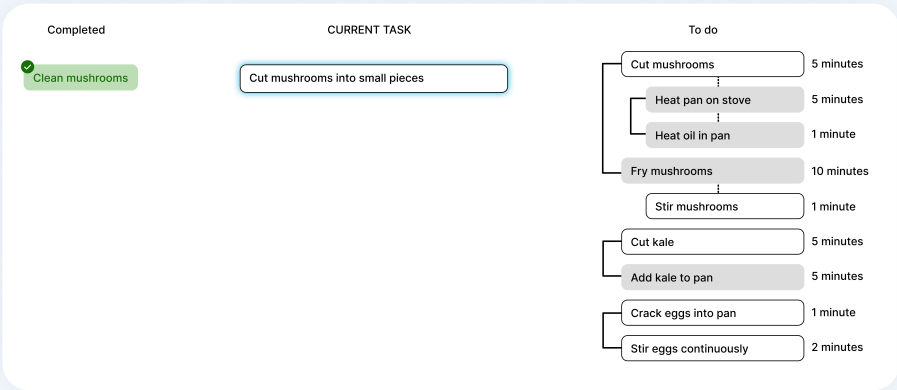


Figure 43. Textual list of tasks

Ingredient & Their Amounts and Tools

This section shows ways that the ingredients, their amounts, and tools could be portrayed. The ingredients and the tools can either all be shown at all times or only the items that are needed for the current task could be shown. Figure 44 shows all ingredients and tools with just images while figure 45 shows all items with just text. Both examples highlight the items that the user needs at that moment. Figure 48 explores how the ingredients can be shown with images and with text in the cooking context. Figure 46 shows the exploration of showing only the immediately relevant ingredients and tools, with images and the amounts with text. Figure 47 shows a visual representation of how the user could be told that an ingredient is split between 3 tasks.



Figure 44. Visual representation of all ingredients



Figure 45. Textual representation of all ingredients

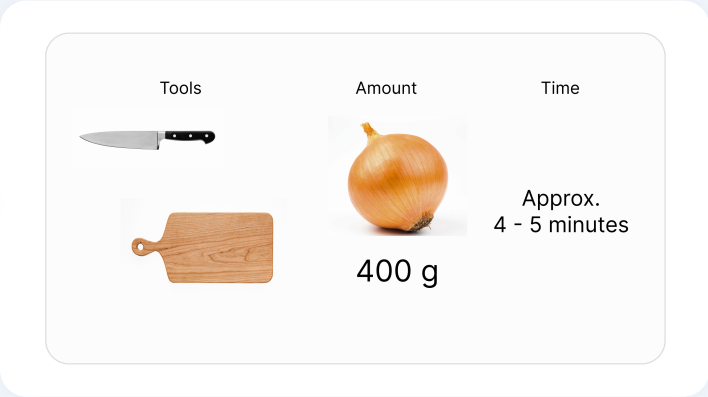


Figure 46. Visual and textual representation of relevant ingredients



Figure 47. Visual depiction of an ingredient that is divided between 3 tasks

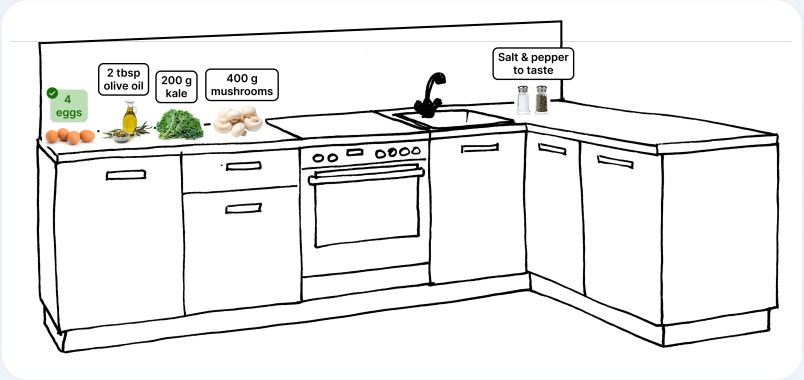


Figure 48. Visual and textual representation of ingredients in the cooking context

Which Task to Do Next & Which is Currently Being Done

The user can be asked which task they would like to do next verbally, visually, or textually. Figures 49 and 50 are both active examples of how the user could be asked which task they would like to do next, where the question is presented obviously. Figure 51 shows how the users could be asked passively where the tasks are stacked indicating that any of the 3 tasks can be carried out next. In all cases, the user answers verbally or with their actions. Figures 52, 53, and 54 show ways that the instructions can be explained to the user. Figure 51 uses images, figure 53 uses words presented in step-by-step format, figure 54 uses video footage.



Figure 49. User being asked which task they would like to do next with visuals

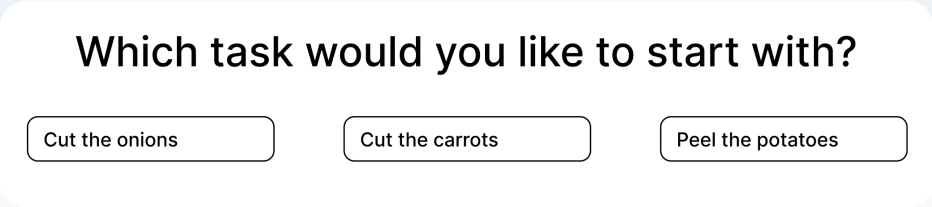


Figure 50. User being asked which task they would like to do next with text

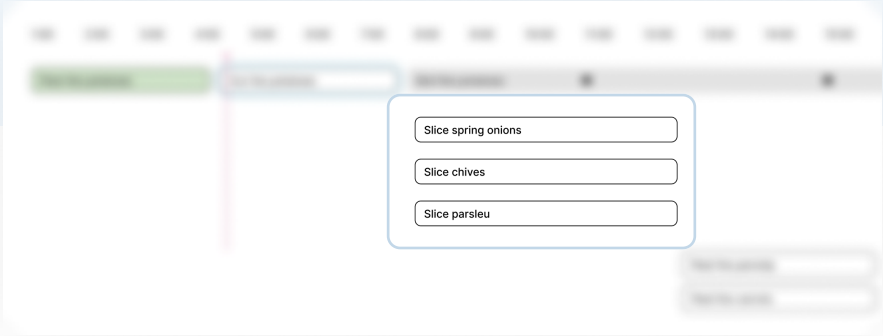


Figure 51. User being asked which task they would like to do next with task placement in timeline



Figure 52. Task instructions with images

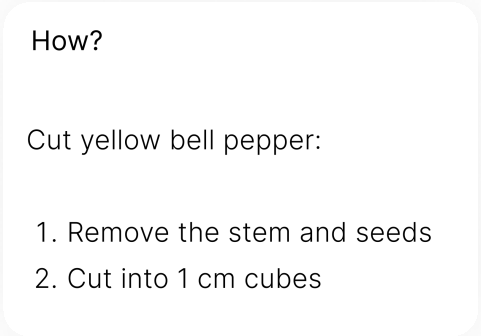


Figure 53. Task instructions with simple step-by-step format



Figure 54. Task instructions with video

Which Tasks Have Been Completed and Which Still Need to be Completed

Figures 55, 56, and 57 use a timeline and colours to show user which tasks still need to be completed, which they should currently be doing, and which have already been completed. The first indication is the red line in figure 55; all tasks to the right of the line still need to be completed, all tasks to the left have been completed, and the task(s) that the line is touching is what the user should currently be doing. This is further demonstrated using colour fills, outlines, icons, and drop shadows. Current tasks, as seen in figure 55, can be displayed using a highlighting drop-shadow. Figure 56 shows upcoming tasks by leaving them in their passive or active state. Figure 57 displays a task that has already been completed using a green colour and check-mark icon (Babich, 2019). In all states, a combination or colour, borders, icons, and drop shadows are used to ensure that users can distinguish between states, even if colour blind (Staats, n.d.). Figure 58 is an example of what deuteranomaly colour blind people would see. Lastly. figure 59 shows the 3 states explained using text.

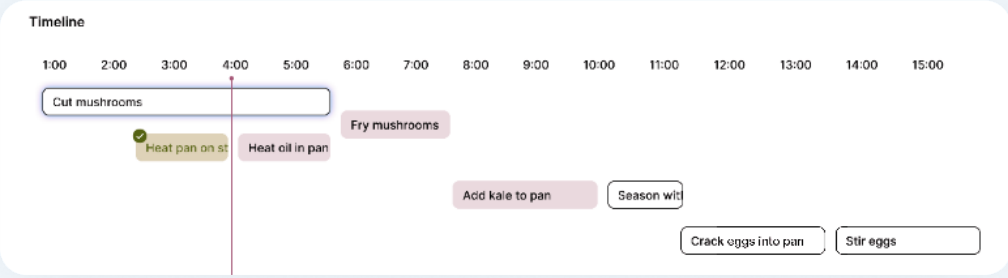


Figure 58. Example of what deuteranomaly colour blind people would see, created using https://www.color-blindness.com/coblis-color-blindness-simulator/

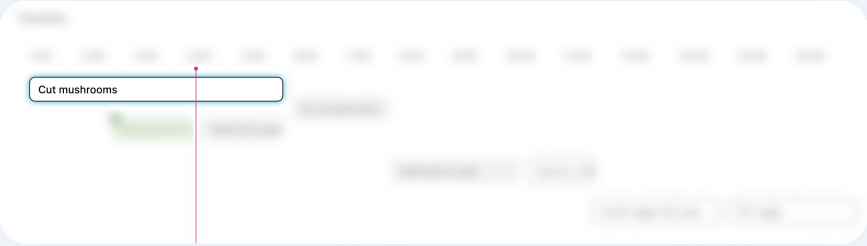


Figure 55. Current task in timeline

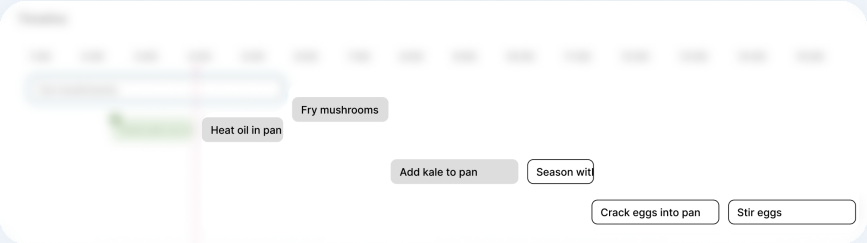


Figure 56. Remaining tasks in timeline



Figure 57. Completed task in timeline

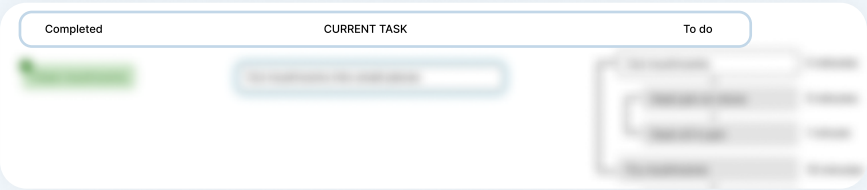


Figure 59. Task states illustrated with text

Cooking Interaction Journey

The Relevant AI section outlined what the intended design needs to know, and the Exploration section explained what the product needs to show. This section uses this information to map out a detailed cooking interaction journey map. This map shows all the possible interactions, that have not been deemed ill-suited, in all the critical interaction moments during the cooking experience.

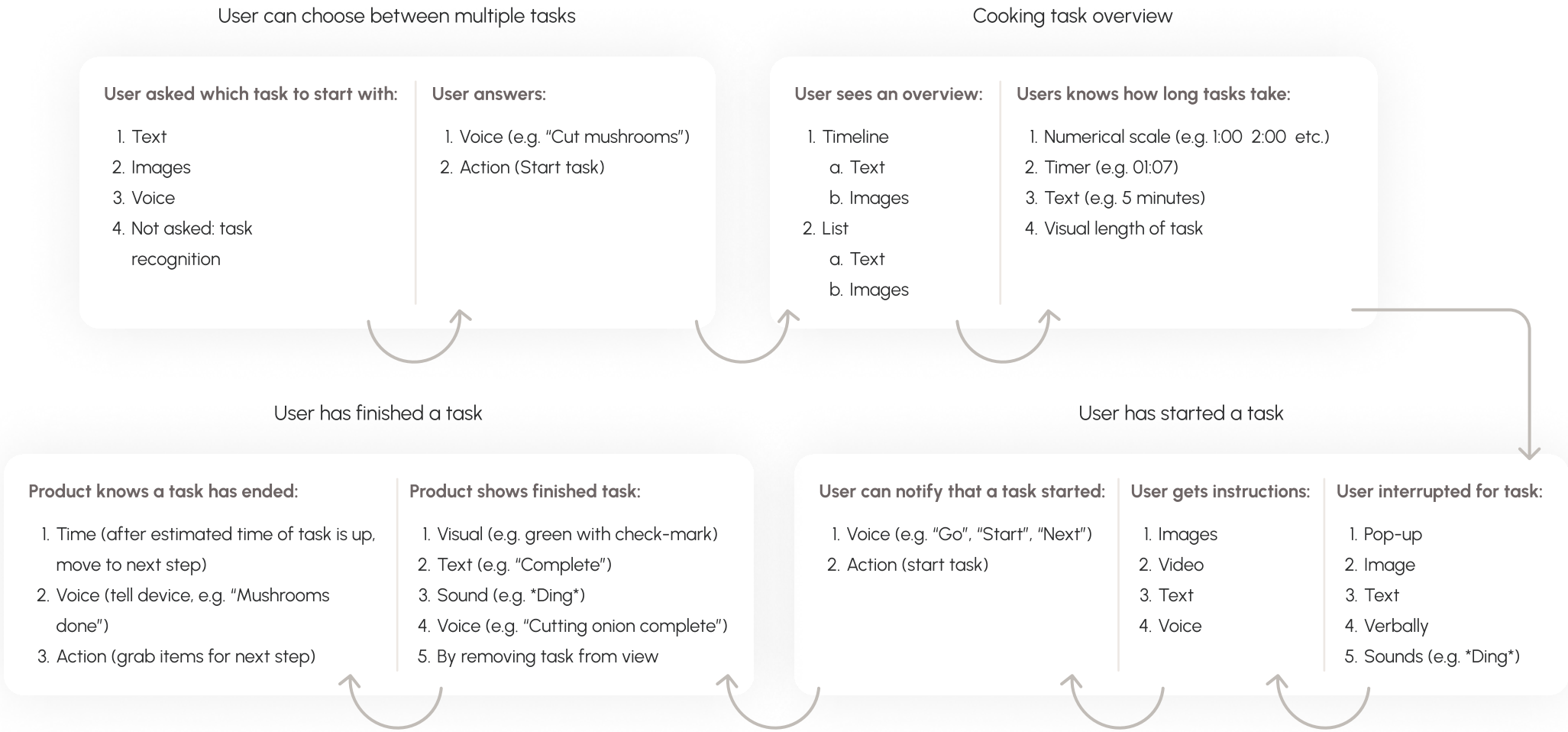


Figure 60. Interaction options mapped out by interaction moments in the cooking journey

Development

The following segment explains how investigating the AI possibilities, exploring how the interface can show information, and the cooking interaction journey led to 2 contrasting prototypes being built to explore the ideal interactions. Firstly, the section explains why and how the prototypes are made with Figma (www.figma.com). Then it explains why 2 prototypes were chosen to be made.

Figma

The prototypes are built in a "collaborative interface design tool" called Figma (Figma, n.d.). Figma is used to create wireframes for websites, applications, etc. as well as logos, icons, and more. Figma was chosen as the tool for creating the prototypes as it has extensive prototyping options that allow for dynamic and interactive prototypes (see figure 61). Additionally, Figma provides the ability to create "components" and "variants". Components are "elements you can reuse across your designs. They help to create and manage consistent designs across projects" (Figma, n.d., Create components to reuse in designs). The main component exists in one location and if any changes are made to it, the changes are automatically applied to all its copies across the project. This allows for quick and easy adjustments to the design.

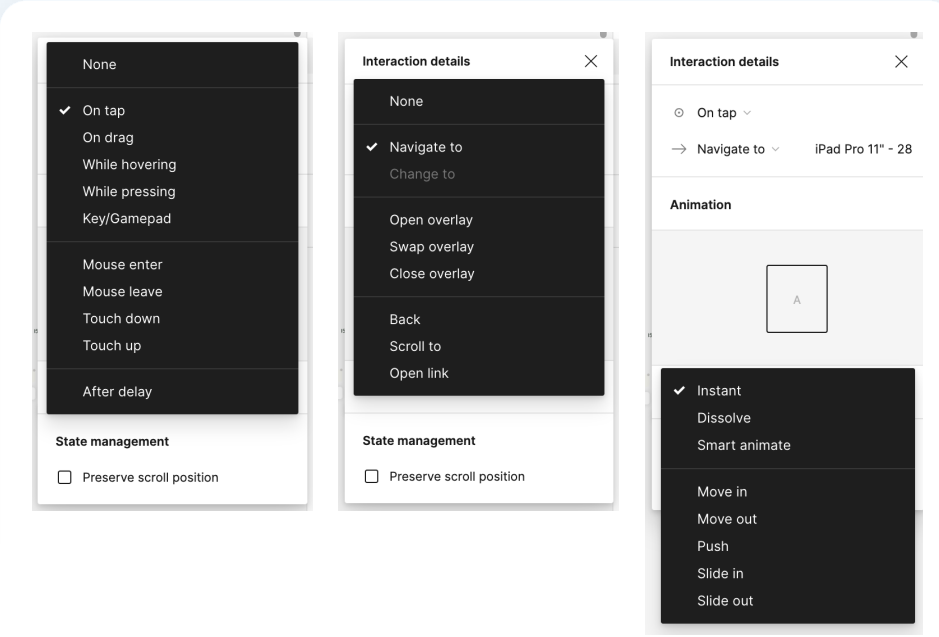


Figure 61. Prototyping options - from left to right: Action to start interaction, what happens after action occurs, which animation is used to change states.

Variants are variations of a component that allow designers to simply switch between states. For example, switching a button from an active to a disabled state. The designer does not have change the colours manually or change the component, but can instead just change the state, see figures 62 and 63. Lastly, Figma was also chosen because it allows for wireframes to be reactive. Simply put, this means that a frame automatically adapts if changed are made. For example, if components are added or removed the frame automatically changed in size to accommodate. In figure 64, the buttons are always 8px apart and there is always padding of 24px on each side of them. That means that if a component is added, the frame automatically expands in order to make the sure the requirements still apply. The designer can also determine that the frame always stays the same and the components adapt within. This is useful for creating a prototype with several frames that need quick adjustments.

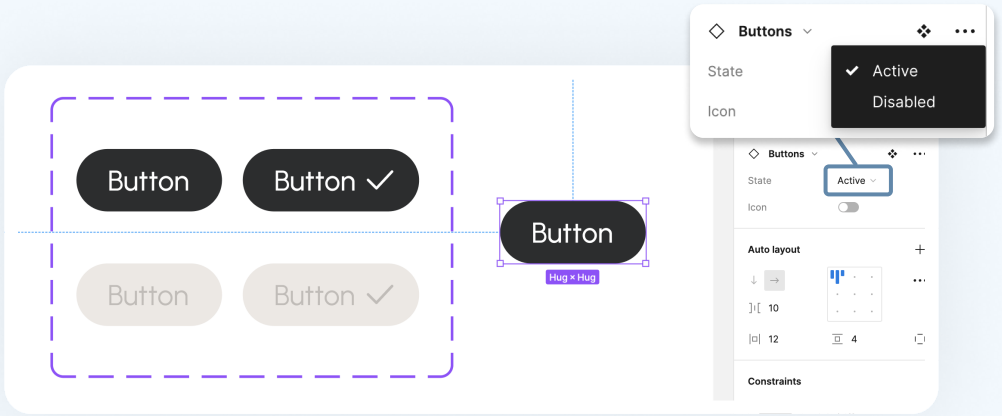


Figure 62. Components & their variants and switching between variants with drop-down

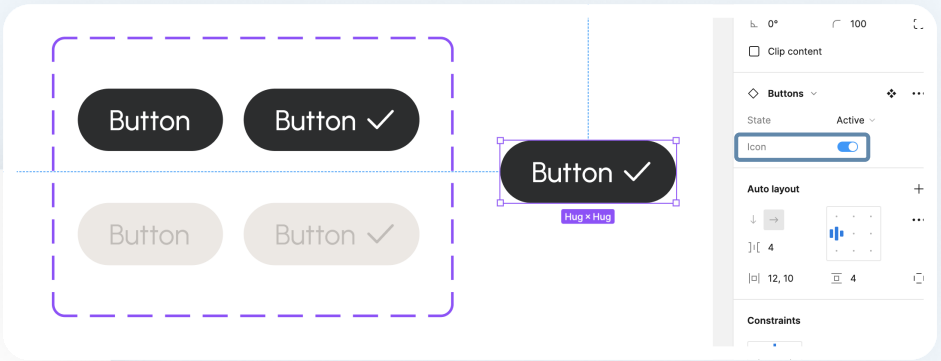


Figure 63. Components & their variants and switching between variants with toggle

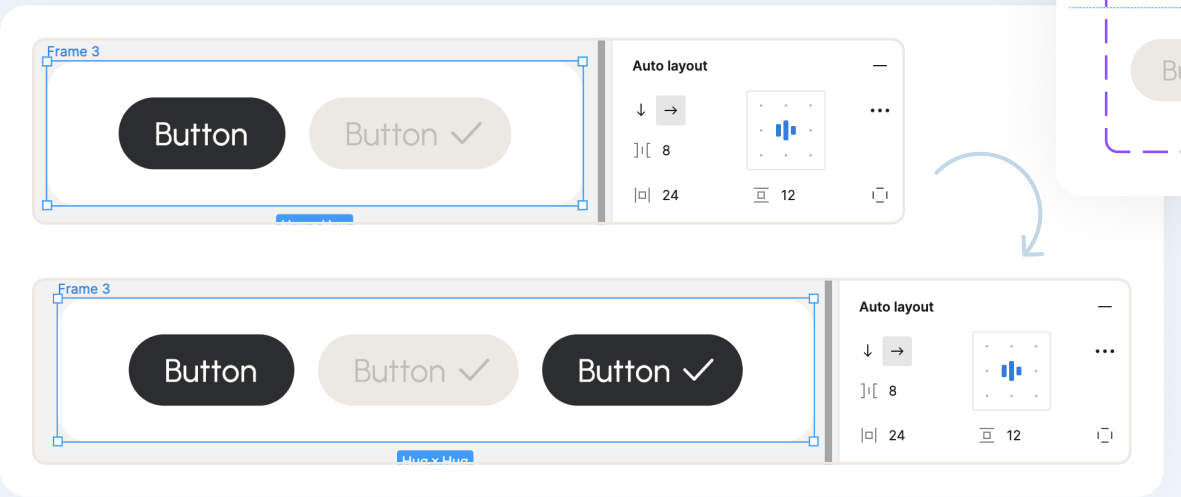


Figure 64. Using auto layout to create a reactive from where there is always spacing of 8px between each button, 24px padding on the sides, and 12px padding on the top and bottom.

Contrasting Prototypes

As a result of the conceptualization phase, 2 contrasting prototypes have been created in order to test the functionality and interactions that users would design in an ideal concept. The conceptualization phase discovered 2 main user-to-product communication methods, verbal and action-based. It outlined several manners in which the product can show information to the user, such as textually, visually, and/or verbally. Lastly, it mapped out moments in the cooking process where these interactions could occur, for example when the user is receiving instructions for a task. Ideally every interaction possibility would be tested in every interaction moment. However, due to time restrictions, the communication methods (both user-to-product and product-to-user) were split into 2 groups to create 2 prototypes. These prototypes were then be tested in all the interaction moments to understand which communication methods are desired in each. The interaction methods were split into a familiar, cognitive, & textual group and an innovative, experiential, & visual group. The prototypes will be referred to as the Text & Action-based (T&A) prototype and the Visual & Verbal (V&V) prototype. Figure 65 shows the grouping from the Cooking Interaction Journey map. The list view for showing the overview of tasks was removed from the prototypes as it does not allow for showing active moments within passive tasks very easily. Additionally. a timeline has been assumed to be a more intuitive representation of the cooking process as it moves with the user. A countdown timer has been removed as a way to show how long a task takes as it may cause the user to feel rushed on a task that may take them more or less time than others. However, users are still reminded to carry out tasks that are time dependent. Instead of a countdown timer, a time estimation will be displayed as a numerical scale for the T&A prototype (assumed to be more cognitive) and written out for the V&V version (assumed to be more experiential). Images have been left out from the prototypes as a method for providing instructions as a video is assumed to provide more information. A simple green component with a check-mark is to be used to show a finished task in both prototypes as it is an intuitive and widely recognized way to display that something is complete (Babich, 2019). Additional communication methods, such as a sound or verbal confirmation, have been left out as it is assumed that that would be an unnecessary interruption to the cooking flow.

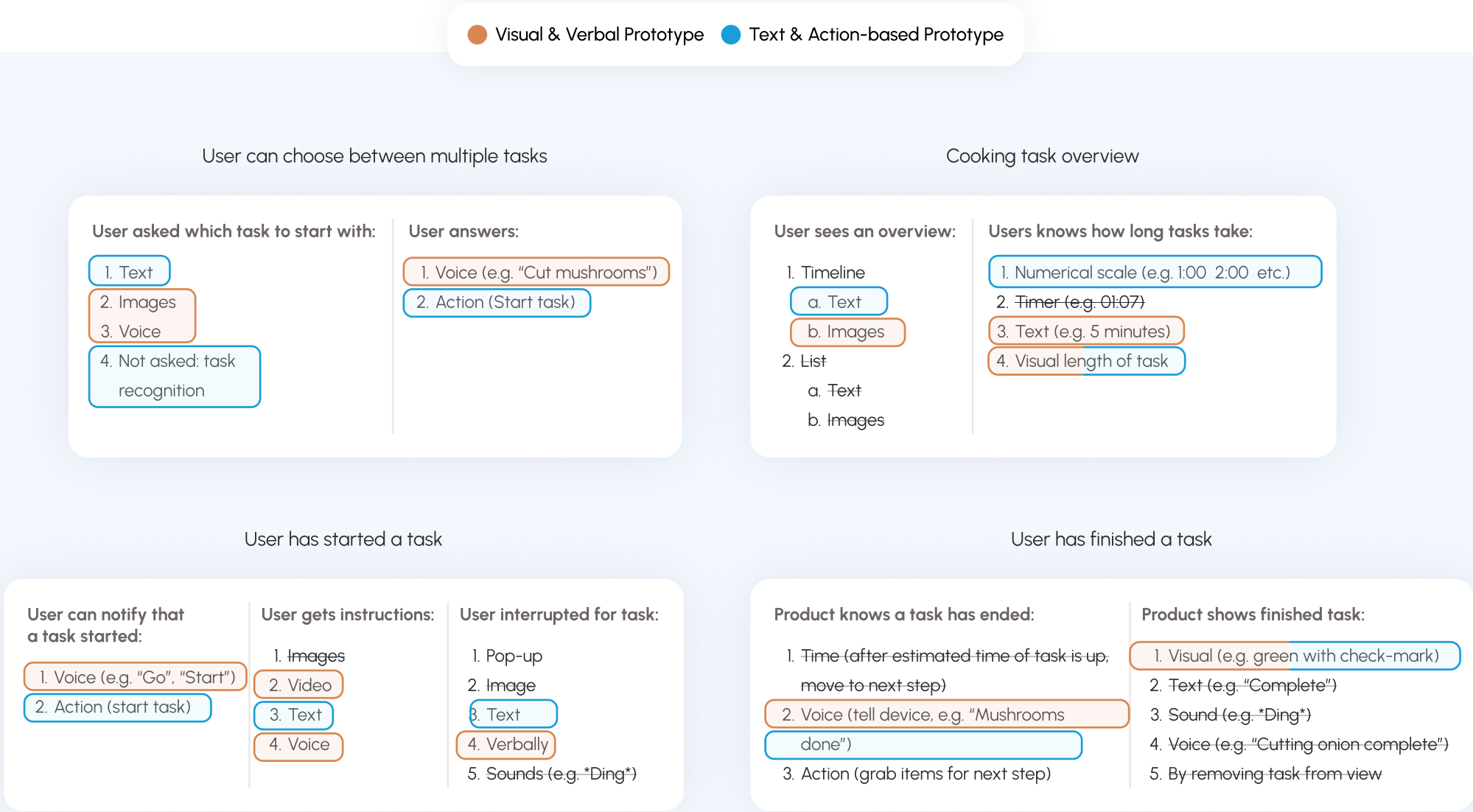


Figure 65. Interaction options mapped out by interaction moments in the cooking journey

Table 12 shows an overview of how all the information in the prototypes has been portrayed in the prototypes. Descriptions in bold highlight the aspects that are different in each prototype whereas normal text shows the aspects that are the same. Varying too many aspects in the 2 prototypes could lead to the user tests being hard to interpret. To apply focus, some elements were not varied between the 2 concepts. The aspects that do not differ were chosen due to industry standards, such as a green check-mark indicating a completed task, or based on the designers discretion.

What the Product Should Show	How	
	Visual & Verbal	***Text & Action-driven***
All steps in recipe	**Timeline with images**	**Timeline words**
Approx. how long steps take	**Size of step component & written out**	**Size of step component in relation to timescale above**
Dependent vs. independent tasks	Shown based on which level they exist on in timeline	Shown based on which level they exist on in timeline
All ingredients & how much	**Images & text**	**Text**
If ingredient is split between steps	N/A for chosen recipes	N/A for chosen recipes
Which task user could do next	Excluded due to prototyping limitations	Excluded due to prototyping limitations
What is currently being done	**Instructions: Video & voice Timeline: Bold blue text & drop-shadow**	**Instructions: Text Timeline: Bold blue text, drop-shadow, & red line**
What has been completed	Green with check-mark	Green with check-mark
What still needs to be done	**Normal state in timeline**	**Normal state in timeline, right of red line**
Passive vs active tasks	Passive: Grey fill Active: White with drop-shadow	Passive: Grey fill Active: White with drop-shadow
User to product communication	**Voice assistant**	**Activity recognition**

Table 12. Interaction type for each prototype. Bold text shows interactions that are different whereas grey shows interactions that are the same.

Visual & Verbal	Text & Action-driven
Affective	Cognitive
Experiential	Efficient
Emotional	Rational
Rich	Functional
Visual	Textual
Friendly	Formal
Open	Reserved
Active	Passive
Innovative	Familiar

Table 13. Descriptive words to compare 2 prototypes

The prototypes have been described and distinguished between with the list of parameters in table 13. The parameters explain the 2 unique personalities of the prototypes. This is to allow the users to easily differentiate and compare the prototypes. They have been constructed by examining the outlined interactions and grouping based on similarities. The Text and Action-driven prototype has been described as cognitive, practical, and functional. The Visual & Verbal prototype has been described as affective, rich, and experiential. The 3 main contrasting word groups have been derived from Córdoba & Jaramillo (2012) and Novak & Hoffman (2003), the remaining words have been attached to provide a deeper impression of the prototype personalities.

The T&A prototype can be described as cognitive as the user receives straight-forward textual instructions that they must read and interpret. This unadorned manner of delivering instructions is also why this prototype has been described as efficient. The user has a goal of cutting the bell pepper and therefore the device simply explains how to do so with a familiar method. Receiving textual instructions is assumed to be familiar to users as it is how most home-cooks currently use recipe instructions. In contrast, the V&V prototype provides video instructions which could evoke more emotion in the cooking process. This prototype take more experiential approach; the user watches instructional videos as well as receive instructions verbally. The task is provided in a longer process, however, it should give the user a richer experience.

With regard to user-to-product communication, the T&A prototype has been described as rational as it uses video recognition technology to follow the user without them having to actively communicate. For this reason and because the device does not produce any sound, it has also been described as passive. The V&V prototype has been described as more emotional as the user can verbally engage with the product. For the same reasons, it has been described as active.

Prototype Recipe

One recipe is used for the prototypes. This is to easily compare the concept user tests of each prototype with each other. This decision was made due to the knowledge gained from the Context Research; using different recipe makes comparison difficult. The chosen recipe needed to be relatively short to cook because the user needs to cook the recipe twice during the user test (once per prototype). Additionally, the recipe needed to accommodate all the dietary restrictions of the participants. Therefore, the participant were contacted in order to obtain their dietary restrictions, before the prototypes were built. There are 2 vegetarian participants as well as participants who dislike mushrooms, chickpeas, green peas, parsley, and black beans. The recipe options were significantly limited due to recipe length limitations, dietary restrictions, and the fact that the recipe had to contain all the interaction moments.

Ultimately a Swapmeals dish called "Wraps with scrambled eggs and bell pepper salad" was chosen as it accommodated all of the dietary restrictions, takes only 15 minutes to cook, and contains all the interaction moments.

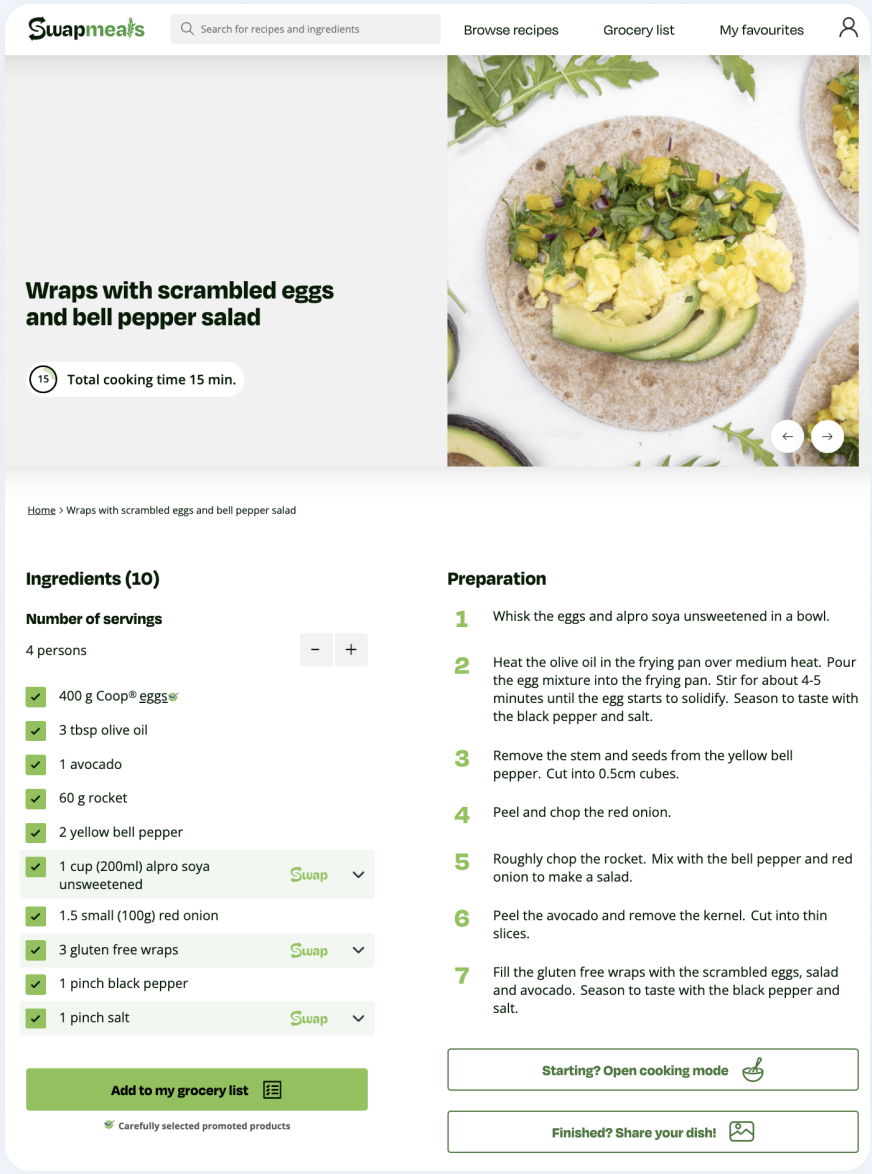


Figure 66. Chosen Swapmeals recipe for prototypes: Wraps with scrambled eggs and bell pepper salad

Prototype Features

The following section describes the features in the prototypes and where they can be seen.

All steps are displayed in a timeline. The task components size represents how long the task will take. It has been chosen as a method for both prototypes because it is both a visual representation and is logical, therefore fitting into both descriptions. The V&V prototype also shows the step length by writing out the time. This is textual, however it is assumed to be more open as it simply tells the user the time (see figure 67, A). The T&A prototype shows the time by plotting the component against a scaled timeline (figure 68, A). This is presumed to be more cognitive as the user can see how far along they are in the process and deduce the task length themselves. Dependent and independent tasks are shown in both prototypes by their placement in the timeline. This is because the connecting lines was only relevant for the list.

The ingredients and tools are shown as images in the V&V version and the amounts written out (figure 67, B). Only showing the ingredients with images (e.g. showing a picture of 4 eggs) was explored, however, it is difficult to show with only an image if a significant amount of an ingredient is needed. Additionally, showing grams with only an image is not clear. Therefore, an image is accompanied by text. For the T&A versions, the ingredients and tools are just shown with only text (figure 68, B). In both prototypes, if a user should be using an ingredient at that moment, the ingredients and tools are highlighted in blue (see figure 67 and 68, C). If the ingredient or tool has been used and will not be used again, they are greyed and crossed out (figure 67 and 68, D). If an item is still needed or will be used again, it remains as the default state.

Next, which task the user would like to do next is also excluded from the prototypes. The reason for this is prototyping limitations; if a user has 3 choices for which task to do then 3 versions must be made to accommodate for all the options. Once a decision is made, the next task will have 2 options resulting in another 2 versions needing to be made per version from the previous step. This means that 6 versions need to be made per prototype per decision. This would take a significant longer time to build, and given the scope of this project it has been removed from the prototypes. This should not be detrimental to the results as the desire for autonomy was proven in the Context Research phase; this phase is to understand the desired interactions with the product. The instructions in the V&V prototype are provided using looped videos as well as verbal instructions (figure 67, E). The videos are 6 seconds to 2 minutes and 42 second long with an average of 52 seconds (see table 14). In contrast, the T&A prototype provides instructions with text and no sound (figure 68, E).

Tasks that have been completed are displayed with a green check-mark and green fill (figure 67 and 68, F). Tasks that still need to be completed appear in their regular state in the timeline for both prototypes. However, in the T&A version, this is further communicated with a red line (figure 68, G). All tasks to the right of the line still need to be carried out. Passive and active tasks are illustrated in the same way in both prototypes. Passive tasks have a grey fill (figure 67, G) while active tasks are white with a drop-shadow (figure 67, H). Passive tasks are grey because this is often the colour chosen for disabled states in user interface design. This is similar to a passive state and therefore is deemed appropriate. If an active moment occurs within a passive task, such as stirring an ingredient on the stove, the moment is shown with a dot (figure 68, H)

Lastly, the user communicates verbally with the prototype in the V&V version and with their actions (activity recognition) in the T&A version. This is because talking is presumably more emotional, friendly, active, and open whereas silently communicating with actions is assumed to be efficient, functional, and passive.

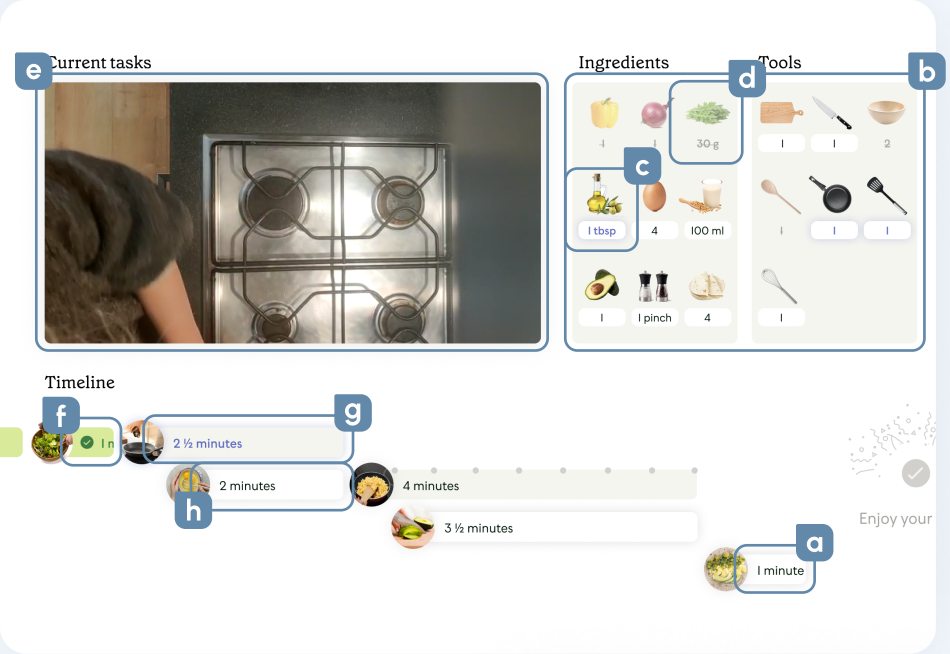


Figure 67. Visual and verbal prototype:

a.) Task length written out (1 minute)
b.) Ingredients and tools shown with images, amounts written out
c.) Current ingredient needed highlighted in blue
d.) Ingredient that has already been used (crossed out)
e.) Looped video instructions
f.) Completed task shown with green fill and check-mark icon
g.) Passive task (grey fill)
h.) Active task (white fill with drop-shadow)

Task	Video Length
Cutting bell pepper	01:04
Cutting onion	01:23
Cutting rocket lettuce	00:10
Mixing salad	00:06
Heating oil	00:27
Mixing eggs	00:40
Cooking eggs	02:42
Cutting avocado	00:52
Combining ingredients	00:36

Table 14. Length of instructional videos

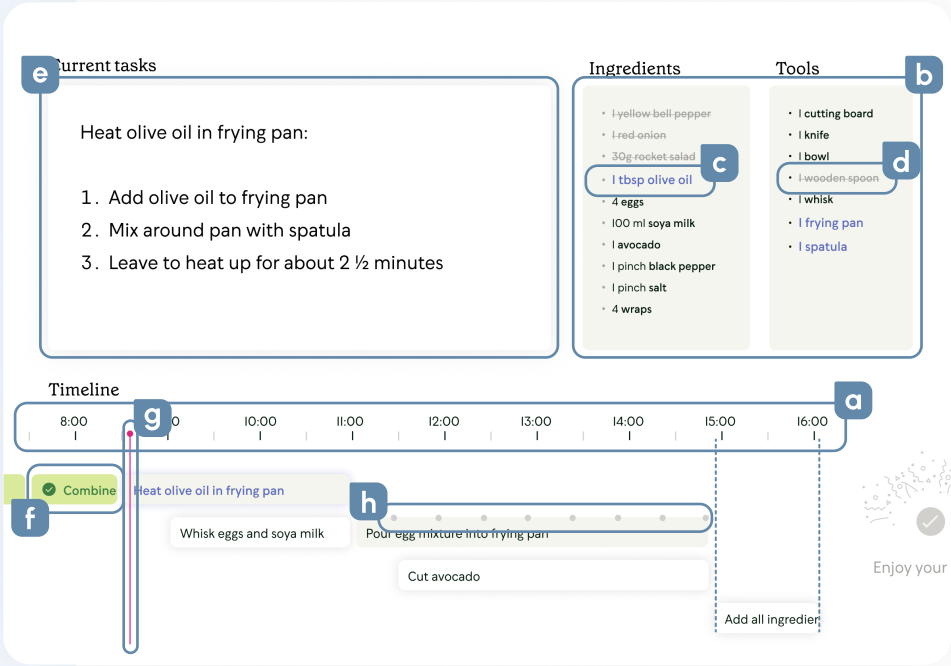


Figure 68. Text & action-based prototype:

a.) Task length shown by where it starts and end on a timeline scale
b.) Ingredients and tools written out
c.) Current ingredient needed highlighted in blue
d.) Ingredient that has already been used (crossed out)
e.) Written out simple step-by-step instructions
f.) Completed task shown with green fill and check-mark icon
g.) Moving red line for timeline (shows location)
h.) Grey dots to indicate active moments in passive task

When 2 tasks need to be carried out simultaneously and the passive task requires the users immediate attention, the user is interrupted with a reminder. A silent textual pop-up appears in the T&A prototype (see figure 69). This is assumed to be slightly passive as the pop-up is silent so the user should only notice the message when they are ready to look at their screen. In the V&V prototype, a visual cue appears in the timeline (see figure 70) and the verbal assistant says the reminder out-loud. The V&V version is meant to be more active as the voice should immediately capture the user's attention.

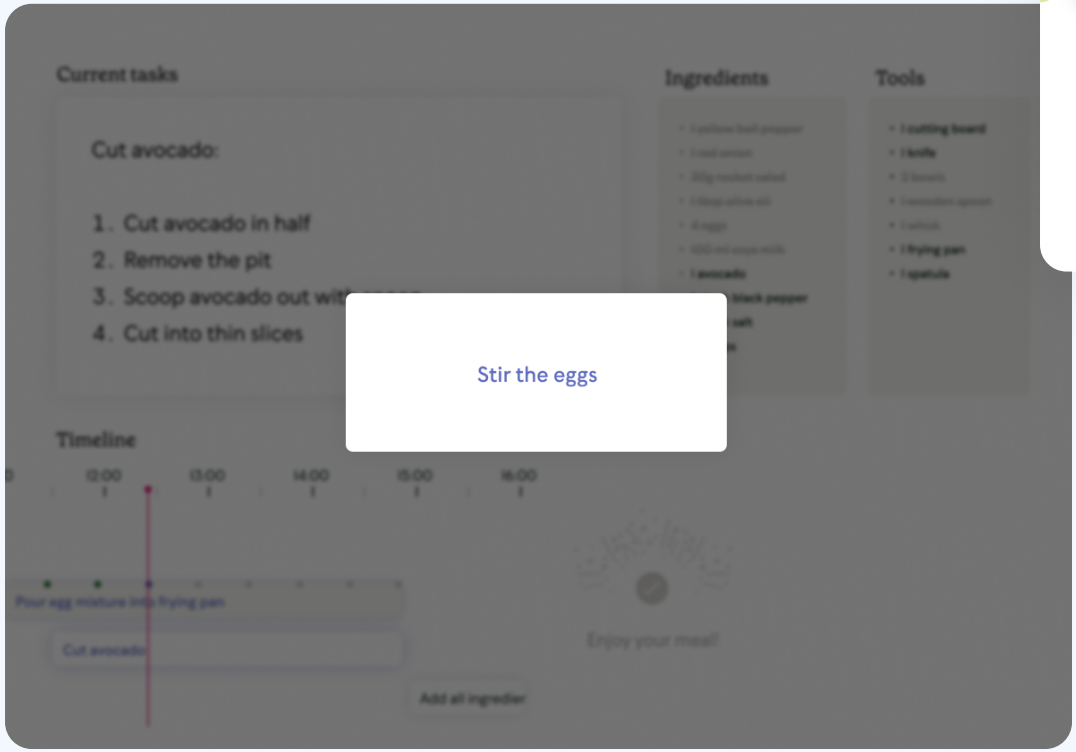


Figure 69. Text and action-based prototype silently communicating with the user that an active action needs to be completed while multitasking

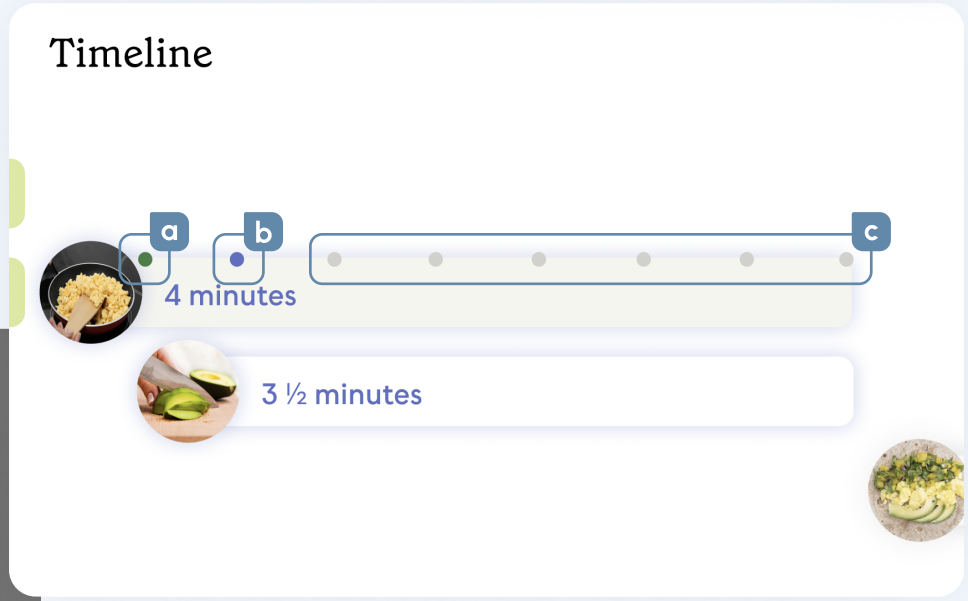


Figure 70. Visual and Verbal prototype during multitasking

a.) Active action within a passive task completed
b.) Active action within a passive task currently needs to be done (instructions given verbally)
c.) Active actions within a passive task that still need to be completed

Building the Prototypes

The prototypes have been built using 25 to 26 frames (see figure 71). When the frame is clicked on in prototype mode, it moves to the next frame (see figure 72). Clicking on the prototype is used as a proxy in user testing for steps in which the AI would recognize a user's action in the final solution. The V&V prototype has a looped instructional video on every frame (see figure 73). The timeline in the T&A prototype can be scrolled through horizontally to give the illustration that it is moving with the user (see figure 74). Additional prototype frames can be found in appendix G.

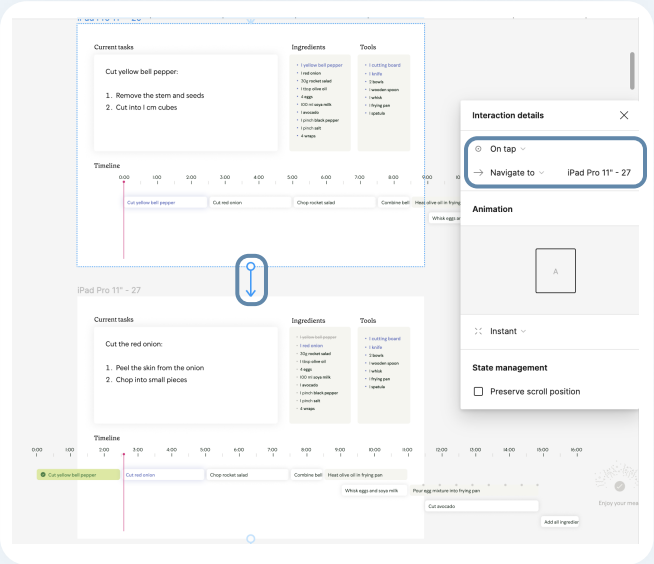


Figure 72. Tapping navigates to the next frame (current task changes state to 'completed')

Figure 71. 25 and 26 frames in each prototype



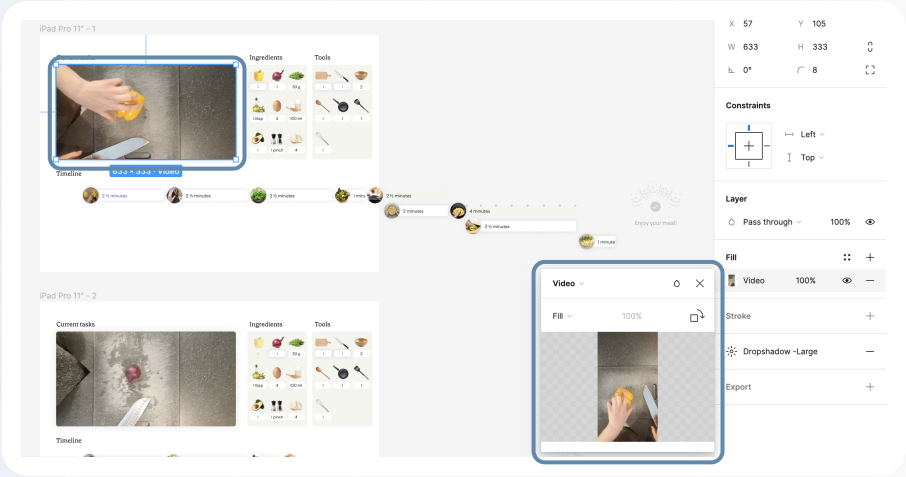


Figure 73. Looped video in 'Visual and Verbal' prototype

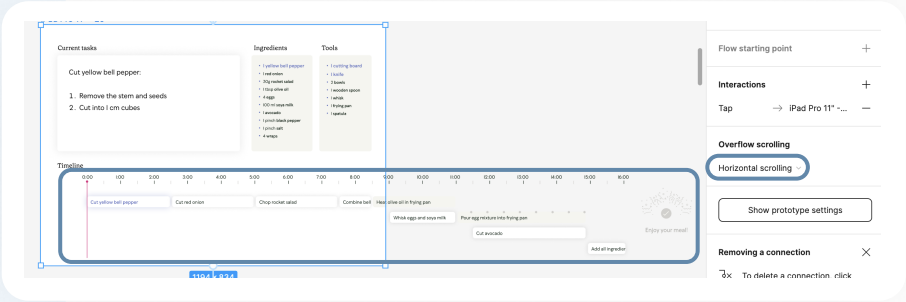


Figure 74. Horizontal scrolling in the 'Text and Action-based" prototype

In both prototypes the current task is displayed in the top left corner as this is assumed to be the most important information. Bakusevych (2018) explains where the users eyes are usually drawn to on user interfaces and therefore where the most important information should be displayed (see figure 75).

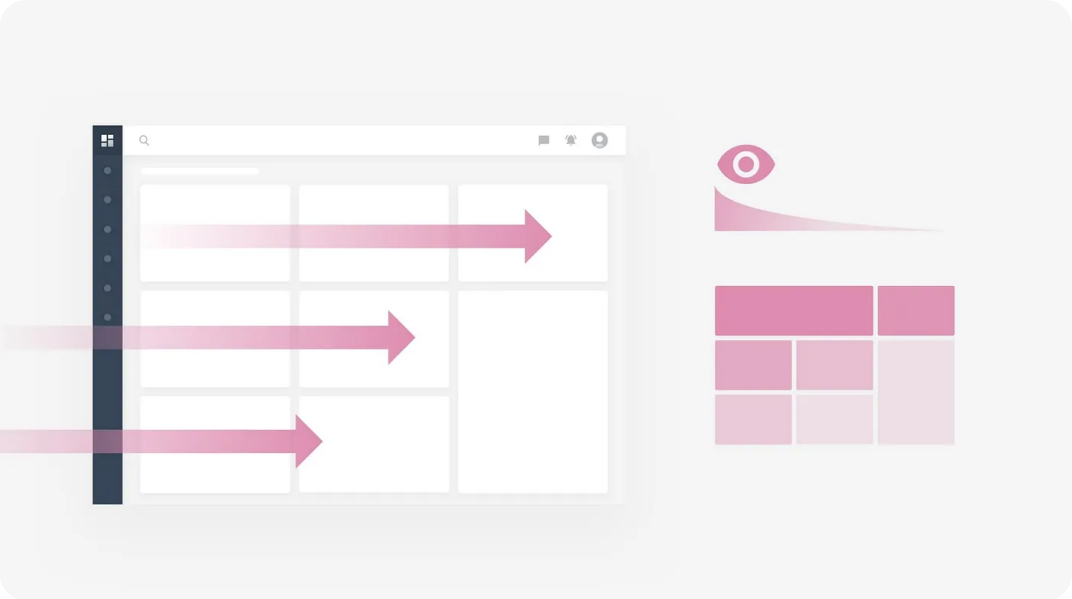


Figure 75. Image showing which areas of a user interface catch the user's attention the most: the most important information should be shown on the top left (Bakusevych, 2018)

06 Concept Testing

The concept testing phase aims to discover which of the proposed interactions are desired by the participants during each interaction moment by asking users to cook a recipe with each of the concept prototypes and then reflect on the experience. The findings from the concept testing were used to propose a final design.

Introduction

The Concept Tests aim to answer which interaction methods the user desires the final design to contain with regard to the following interaction moments:

01 Receiving an overview of the cooking tasks:
- How the user can see the overview
- How the user can know how long each task will approximately take

02 When the user has started a task:
- How the user can tell the device that they have started a task
- How the user can receive instructions from the device
- How the user can be interrupted when an active moment occurs in a passive task

03 When the user has finished a task:
- How the device can know that a task has ended
- How the device can show the user that they know the task has ended

Method

The concept tests were conducted using interviews, observations, reflections, and comparison techniques. In contrast to the Context Research, the participants did not have to come up with a recipe to cook or purchase the ingredients. This was provided by the researcher as all the participants cooked with the same recipe.

Ethical Considerations

Participants were asked to provide permission for audio and video recordings to be taken during the sessions. Photos taken and used in this report have been also approved by the participants. They were asked to fill in the same informed consent form from "Context Research" session in order to carry out the test ethically and safely.

Participants

The concept tests were completed with a total of 6 participants in 6 kitchens. The number of participants is even in order to equally alternate between which prototype the user receives first. None of the participants took part in the Context Research. The participants were aged between 23 and 52 and consisted of 5 females and 1 male (see table 15). The participants were recruited through personal connections. Every participant possessed a post-secondary education with careers in fields such as engineering and marketing.

Age	27	23	27	52	51	27
Gender	Male	Female	Female	Female	Female	Female

Table 15. Age and gender of participants - not in chronological order as to protect their identities

Procedure

The concept tests were conducted with each participant in their homes. Each session lasted approximately 1 hour.

Session Opening

The participant was asked to read and sign the informed consent form (appendix C) and give permission for audio and video recordings. Afterwards, the researcher explained the contents of the study, approximately how long it would take, and let the participants ask questions.

Preliminary Interview

The session started with the same preliminary interview from the "Context Research". This was to allow the 2 studies to be directly comparable. It also enabled the interviewer to determine whether or not the participants fit the target user.

Cooking Session Opening

After the preliminary interview, the first prototype the participant would receive was explained in more detail. If they were to receive the Text & Action-based prototype first then they were told that they would receive instructions in a textual manner and that the prototype would know where they are in the process using activity recognition technology. They were told that the prototype does not contain this technology and instead the researcher would act as the technology. They were asked to behave as if the research was not present. If the participant received the Visual & Verbal prototype first then they were told that the prototype would provide recipe instructions verbally accompanied by videos and images. They were informed that they would need to communicate verbally with the prototype. They were provided with command examples such as, "Start", "Next Step", and "Cut onions".

The participants were then asked where they would normally set up their recipe instructions device in the kitchen. The laptop, containing the prototypes, was placed in this location and a phone was set up to record the session (see figure 76).

Figure 76. Example of observation set-up in one of the participants kitchens



Cooking Session

After the set-up, the participants started cooking with the prototypes. For the T&A version, the prototype would begin by letting the participant know that the experience would start once they grabbed the first ingredient (figure 77). The researcher did not verbally communicate with the participant after the session began. The user was expected to familiarize themselves with the prototype and initiate the cooking instructions themselves by following the instructions in the "Current Tasks" box. Once the participant grabbed the yellow bell pepper, the task instructions would appear in the "Current Task" box (figure 78) and the timeline would be moved with their progress, by the researcher. When the participant completed a task, the researcher would click on the prototype and the next instructions would appear (see figure 79). This process repeated itself for every task.

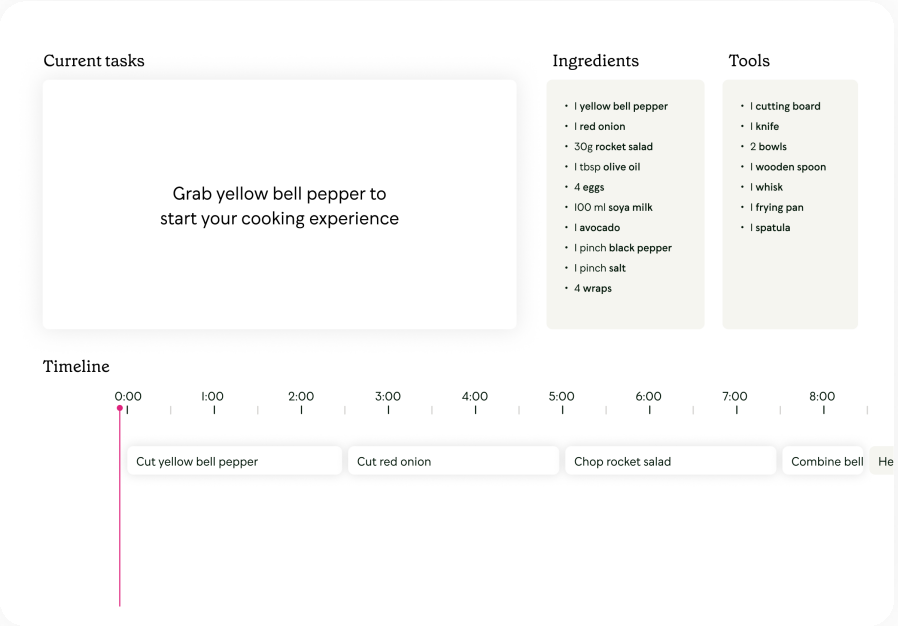


Figure 77. Starting page of Text & Action-based prototype

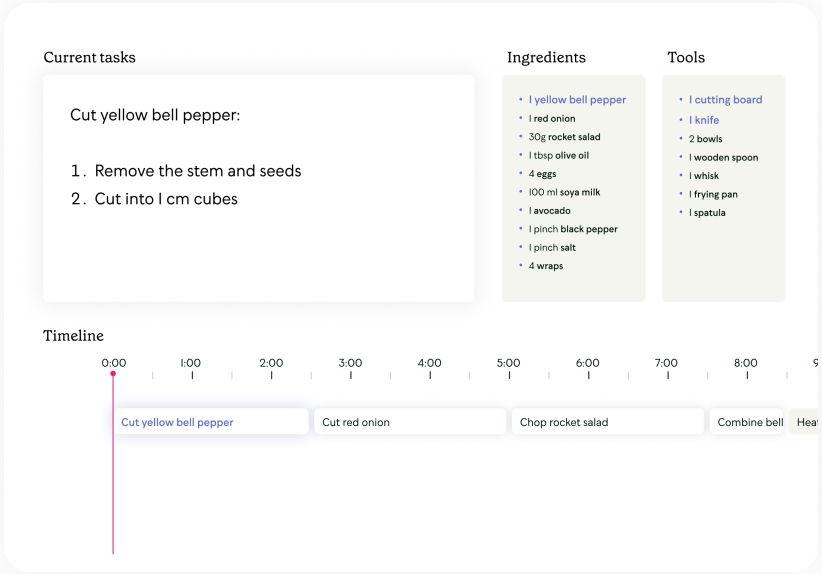


Figure 78. First task instruction of Text & Action-based prototype

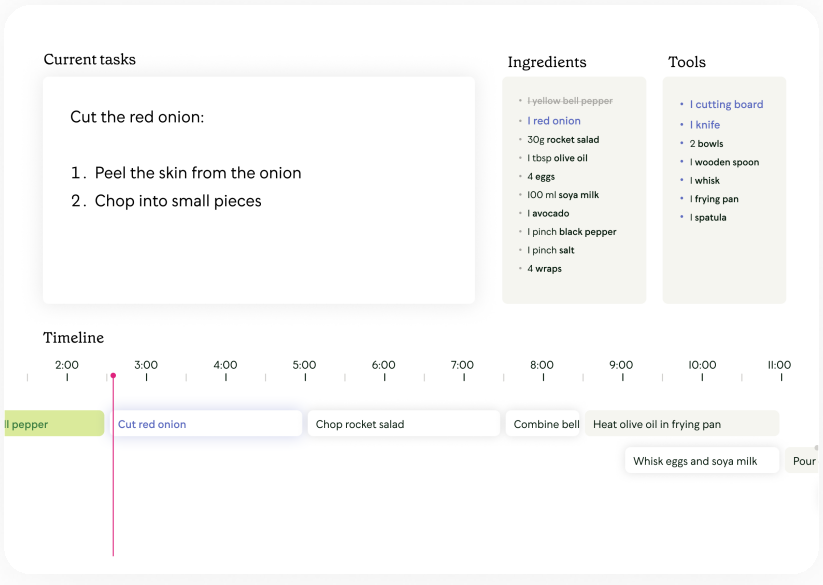


Figure 79. Second task instruction of Text & Action-based prototype

When the participant received the V&V version, the prototype would start with the screen seen in figure 80. The participant was previously told that the instructions would appear once they said "Go", "Start", "Start cutting bell pepper", etc. Once the participant did so, the researcher would click on the prototype, the screen would change to figure 81, and the researcher would provide the instructions verbally. A list of the verbal instructions can be found in appendix F. When the participant completed the task, the researcher clicked on the prototype to show the next instruction (see figure 82).

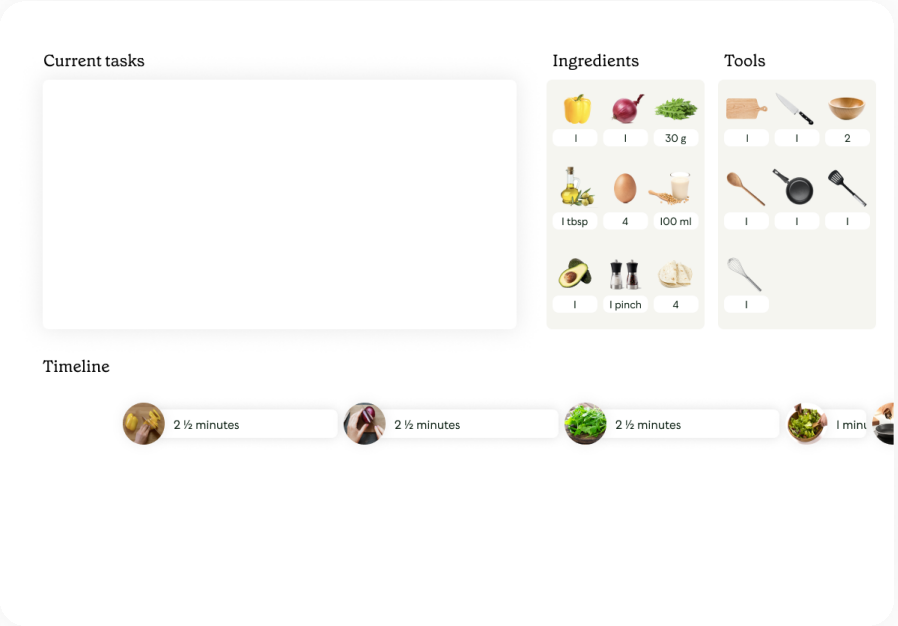


Figure 80. Starting page of Visual & Verbal prototype

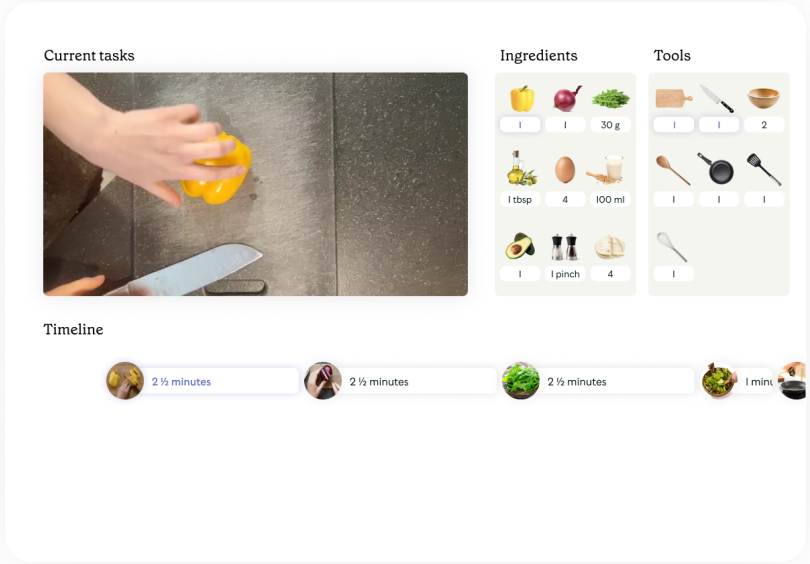


Figure 81. First task instruction of Visual & Verbal prototype

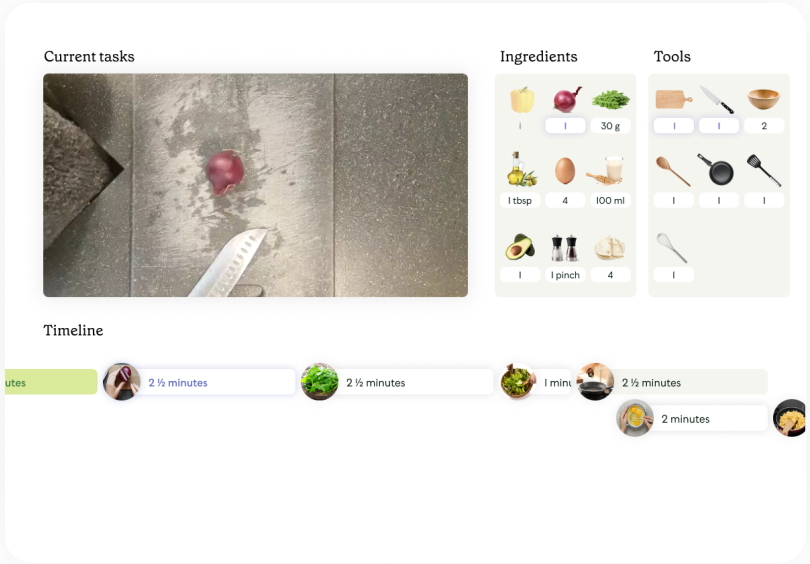


Figure 82. Second task instruction of Visual & Verbal prototype

When the participant reached the multitasking part of either prototype, the researcher watched the eggs cooking and clicked on the prototype to remind the user when to stir the eggs when necessary (figure 83 shows T&A, figure 84 shows V&V). When the eggs were ready, the researcher clicked to the screen to have the prototype explain that they need to remove the eggs from the stove (figure 86 shows T&A, figure 85 shows V&V).

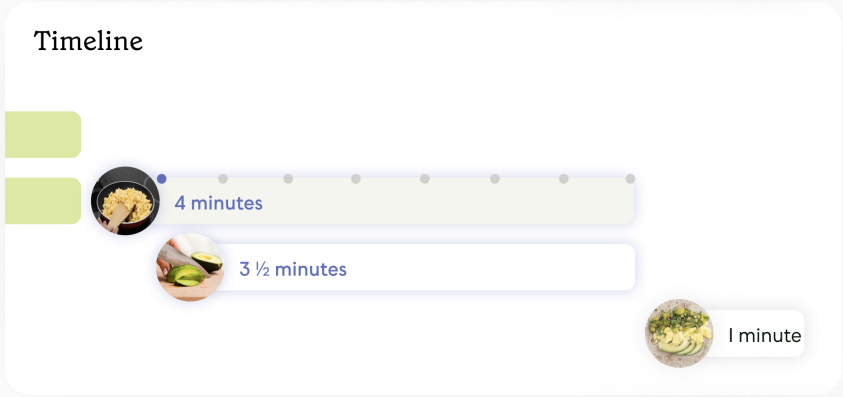


Figure 84. V&V visual reminder to stir eggs in addition to verbal reminder



Figure 85. V&V visual reminder to remove eggs from heat in addition to verbal reminder

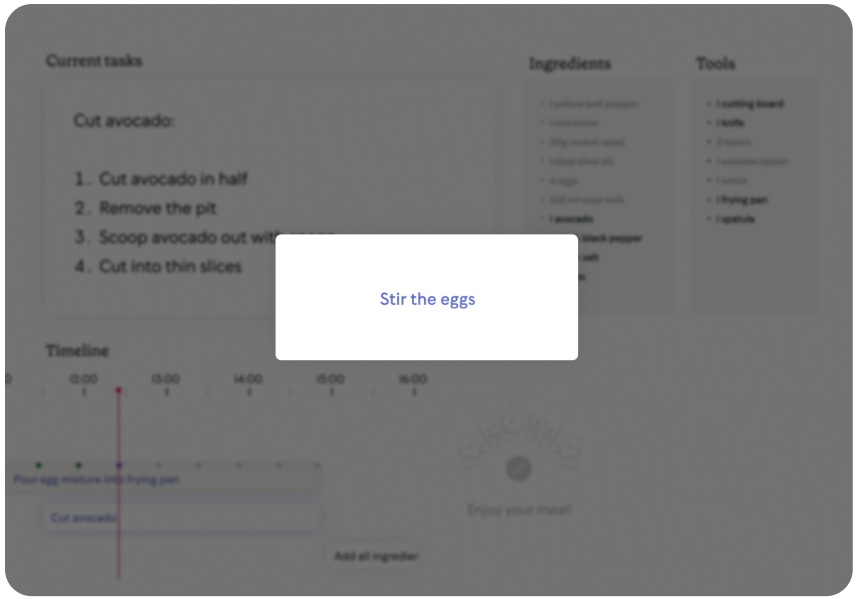


Figure 83. T&A reminder to stir eggs

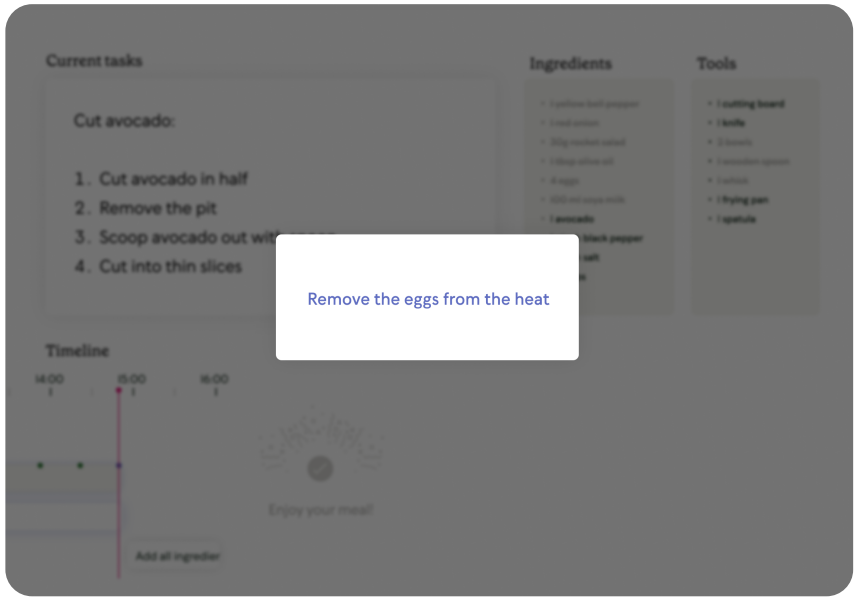


Figure 86. T&A reminder to remove eggs from heat

Participant Refection

After the participants used each of the prototypes, they were asked to reflect on the experience. They were asked to reflect using the retrospective think-aloud (RTA) protocol (Chee, 2019), in contrast to the concurrent think-aloud protocol used in the Context Research. The RTA protocol asks users to explain their thought process after they have completed tasks by retracing their steps. This method was chosen as having the users explain their thought process during the session would be difficult due to the fact that they were interacting with the prototype. The users were asked to retrace their experience of the interaction moments by looking back at the prototype (or video footage). They were asked to explain what they liked and disliked about the experience and interface. The participants were then requested to reflect on the following aspects after using each prototype:

01 Task overview representation

02 Representation of time each task takes

03 User-to-product communication

04 Instruction method

05 Interruption method

06 Interface design / layout

Comparison Interview

After the participant had cooked the recipe with each prototype and reflected on the experiences, they were asked to compare the prototypes to each other. This was done to understand what they preferred and what they would change to create an ideal product. Table 16 is a reminder of the differences between the prototypes for each reflection topic.

Reflection Topic	Visual & Verbal	Text & Action
Task overview	Timeline with images	Timeline with text
Time each task takes	Written out	Timeline scale
User to product communication	Verbal	Action-based
Instruction method	Verbal and videos	Textual
Interruption method	Verbally with minor visual cue	Textual pop-up
Interface design / layout	Current tasks, ingredients, tools, and timeline	Current tasks, ingredients, tools, and timeline

Table 16. Comparing methods used by V&V and T&A prototypes in relation to reflection topics

The participants were shown each prototype side by side and asked the following questions:

01 Which aspects did you prefer in each prototype?

02 Would you remove any aspects?

03 Would you change any aspects?

04 Would you add any aspects?

Then the participants were asked how they think cooking with their described adjusted product would compare to their current recipe instruction method. If they did not mention it in their answer, they were asked to think about how it would affect their emotions, the feeling of being in control, and cognitive load. Then they were asked if they think cooking with their adjusted product would affect the cooking difficulty. Lastly, the user was asked if they think they would use this adjusted product if it was available. This was asked to get an initial understanding of whether the users would adopt an instruction-based cooking product.

Session Wrap-up

The sessions were concluded by eating the cooked recipe and cleaning up. Any leftover ingredients were left behind.

Analysis

The goal of this analysis was to investigate the qualitative data in order to answer which interaction methods should be used in the interaction moments in order to create an ideal prototype. Conclusions from the user test have been drawn by again using thematic analysis techniques, where the data was coded and clustered. This approach discovered the main themes of the research in the format of design insights. The process combined a deductive and inductive coding approach. This means that the data was interpreted and coded using the existing knowledge from the Context Research as well as new discoveries. The analysis was mostly semantic, meaning that the themes were uncovered using what the participants explicitly stated and not the researchers interpretations (Braun & Clarke, 2006).

The audio recordings from the preliminary interviews, reflections, and comparison interviews were transcribed from 1 hour, 50 minutes, and 32 seconds of speech to nearly 50 pages of text. Note that the line changed per speaker. This was done in order to simply refer back to the dialogue to extract messages. The speaker was also identified in the transcriptions to know who is speaking.

Preliminary Interview

The transcribed answers from the preliminary interview, with the exception of the participants age, gender, and occupation, can be seen in table 17.

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
Recipes per week	1	1	1 -2	0	2	0
Time spent per day (hours)	0.75	1	1.25	1	0.5	0
Cooking level	Competent	Advanced beginner	Competent - Proficient	Proficient	Competent	Advanced beginner
Dietary restrictions	No pork	Vegetarian	No	No	Cashew allergy, vegetarian	No
Usual cooking method	Freestyle	Half instructions, half freestyle	No instructions	No instructions	Read ahead & adjust (mix)	Does not usually cook
Preference	Result: instructions, Process: freestyle	Read recipe & adjust	Without instructions	Without instructions	Mix / With instructions	With instructions
Cooking company	Alone	With partner	Alone	Alone	Alone	Alone (when they do cook)
Cooking enjoyment	Somewhat (3/5)	Quite a bit (4/5)	Quite a bit (4/5)	Very much (5/5)	Somewhat (3/5)	Not very much (2/5)
Cooking style	Life learner, Balance seeker	Hungry hustler	Hungry hustler, Curious cook	Proud plater, Curious cook	Hungry huster, Balance seeker	Life learner, Balance seeker

Table 17. Table of opening interview answers

Prototype Order

The prototype that the participant used first was alternated for each test in order to determine whether the comments were related to the prototype itself or merely which prototype they used first. The prototypes that the participant used first can be seen in table 18.

Participant	1	2	3	4	5	6
Visual & Verbal	1st	2nd	1st	2nd	1st	2nd
Text & Action	2nd	1st	2nd	1st	2nd	1st

Table 18. Which prototype the participant received 1st and 2nd

Coding

Quote fragments are extracted from the transcriptions of the participants reflections and comparison interviews that show what the participant is conveying. In contrast to the Context Research these are not the researcher's interpretation of what the participant means but instead is condensed quotes. These quotes were then written out on notes to be coded. The initial codes were obtained using a combination of deductive and inductive coding. The deductive codes were generated from the interaction moments as well as from the design goal and interaction vision (see table 19 for the list of codes). The inductive codes were generated while reviewing the notes. The notes were then organized into their corresponding codes (see figure 87).

Deductive Codes	Inductive Codes
Timeline with images	Having amounts in instructions
Timeline with text	Other
Task time written out	
Task time on scale	
Verbal interruptions	
Pop-up interruptions	
Verbal user to device communication	
Action-based user to device communication	
Video instructions	
Verbal instructions	
Textual instructions	
Ingredients & tools with images	
Ingredients & tools with text	
Cognitive load	
Interaction vision	
Sense of control	
Interface design / layout	

Table 19. Deductive and inductive codes

What they like | What they dislike | V&V (reflections) | T&A (reflections) | V&V (comparison) | T&A (comparison) | Neutral comparison



Table 87. Coded notes from reflections and comparison interviews.

Clustering

After the notes had been organized into their code topics, they were further organized into clusters to be able to identify themes. The clusters were created based on the general patterns that the researcher identified from the coded notes. The cluster categories and their corresponding code topics can be seen to the right. The clustering of the notes can be seen in figure 88.

01 **Timeline**
- Timeline with images
- Timeline with text
- Task time shown on a scale
- Task time written out

02 **User-to-device communication**
- Action-based communication
- Verbal communication

03 **User interface layout and design**
- Having amounts in instructions
- Ingredients & tools as images
- Ingredients & tools as text
- Interface design / layout

04 **Interruptions**
- Verbal interruptions
- Textual pop-up interruptions

05 **Instructions**
- Verbal instructions
- Textual instructions
- Video instructions

06 **Design brief**
- Cognitive load
- Interaction vision
- Sense of control

07 **Other**

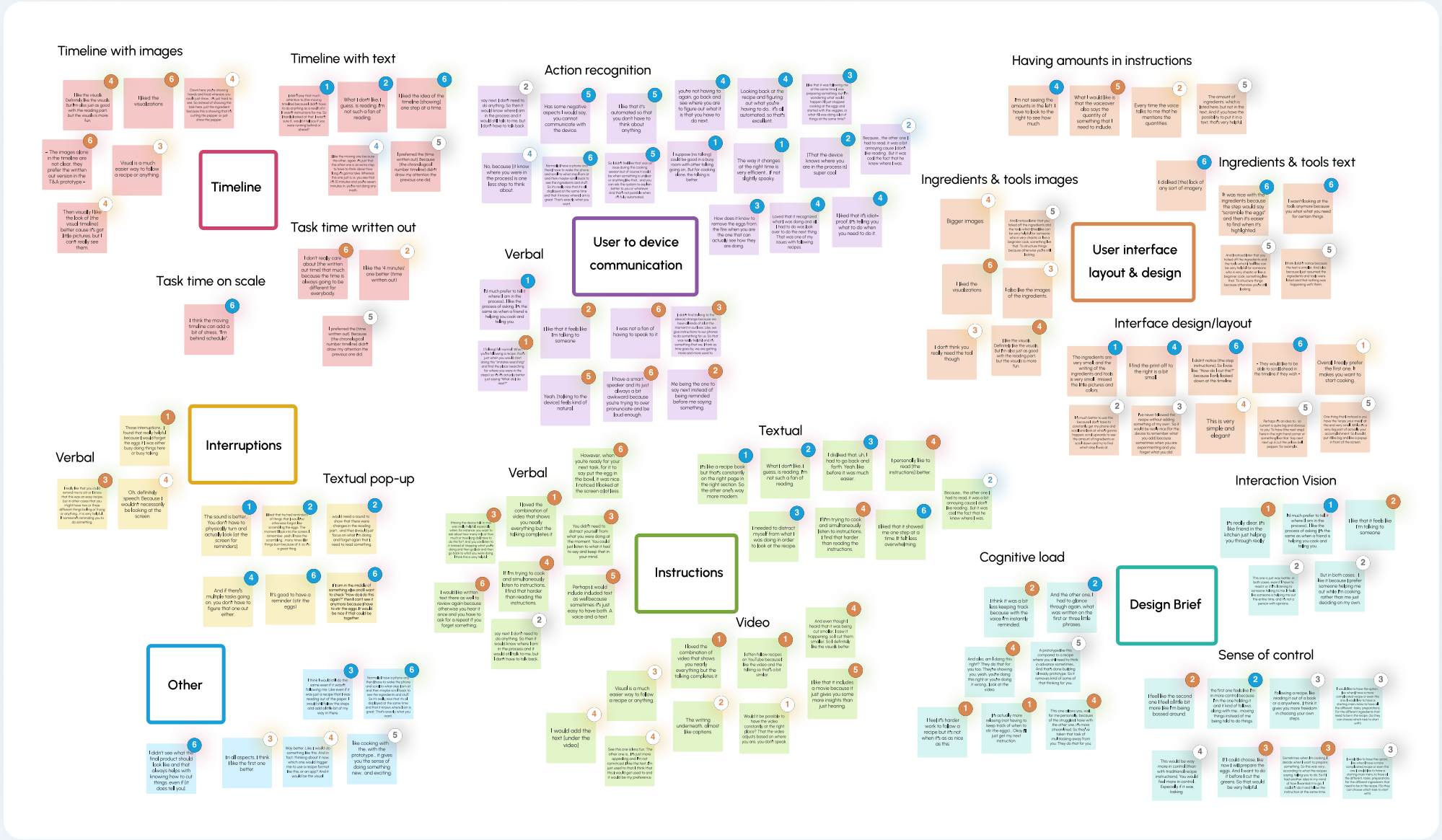


Figure 88. Clustering of code topics

Results & Insights

The following section describes the results and insights that were discovered from the analysis. They have been divided into 2 parts: 'Design Insights' and the 'Initial Design Brief Validation'. The Design Insights draw conclusions from the participants reflections and comparison interviews that are relevant to creating the final design proposal for this project. The Initial Design Brief Validation is the beginning of validating whether the concepts are moving in the correct direction and whether they are capable of satisfying the framework defined in the Design Brief.

Before the Design Insights and the Initial Design Brief Validation are outlined, table 20 shows an overview of the participant's interaction method preferences per reflection topic. All 6 participants preferred the Visual and Verbal prototype for the majority of the reflection topics. However, the activity recognition from the Text and Action-based prototype had the majority preference with regard to user-to-product communication. Similarly, 4 out of 6 participants would like to have the text from the T&A prototype, in addition to the video and verbal instructions from the V&V prototype.

Reflection Topic	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
Task overview	Visual	Visual	Visual	Visual (But wants bigger images)	*No preference*	Textual
Time each task takes	*No preference*	Written out	Written out	Timeline scale	Written out	*Finds it irrelevant*
User to product communication	Verbal	Action-based	Action-based (But skeptical if it would work)	Action-based	Mix of both	Action-based
Instruction method	Video & Verbal	Video & Verbal (With text)	Video & Verbal	Video (With text)	Video & Verbal (With text)	Video & Verbal (With text)
Interruption method	Verbal	Verbal	Verbal	Verbal	Verbal	Verbal
Interface design / layout	Visual	Visual	Visual	Visual	Visual	Visual

Table 20. Interaction method preference for each reflection topic from the comparison interview. Orange represents the interaction methods from the Visual & Verbal prototype and blue represents the methods from the Text & Action-based prototype

Design insights

5 recurrent insights emerged from the concept testing analysis. These insights explain the aspects that the participants desire in order to create their ideal design solution.

01 Visual representations are desired over text

02 Participants would like to have instructions provided with mixed-media

03 Most participants would like the device to recognize their activities

04 Interruptions should have a sound and should not block the other instructions

05 The participant's attention is too divided across the different sections of the concept's interface

The participants that associate with the insight are portrayed with the following visualization:



This examples shows that participants 1, 4, and 5 associate with the theme whereas participants 2 and 3 do not.

01 Visuals over Text

All 6 participants preferred the visual representations of the ingredients, tools, steps, and instructions over the textual alternatives. The visuals were described as fun and modern and the participants conveyed that they were easier to understand in a shorter amount of time. Participant 4 initially selected the textual information as having their preference. However, once they got more familiar with the visuals they changed their preference. They explained that the text was familiar, and therefore they thought it had their preference, yet, they ultimately decided the visuals were more appealing. Participant 6 preferred images everywhere except for in the timeline where they found the text easier to interpret.

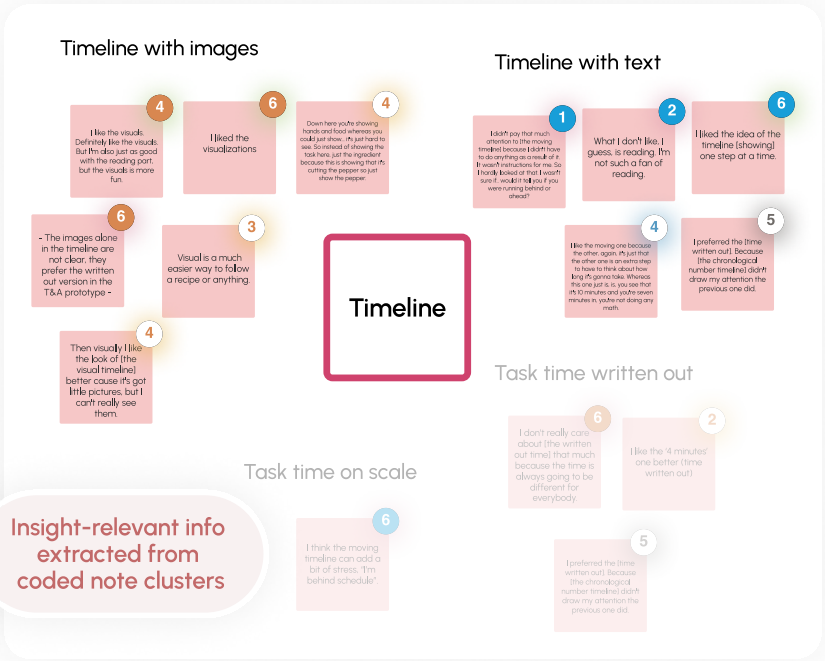


Figure 90. Comments on visuals from 'Timeline' cluster



Figure 89. Comments on visuals from 'User interface layout & design' cluster

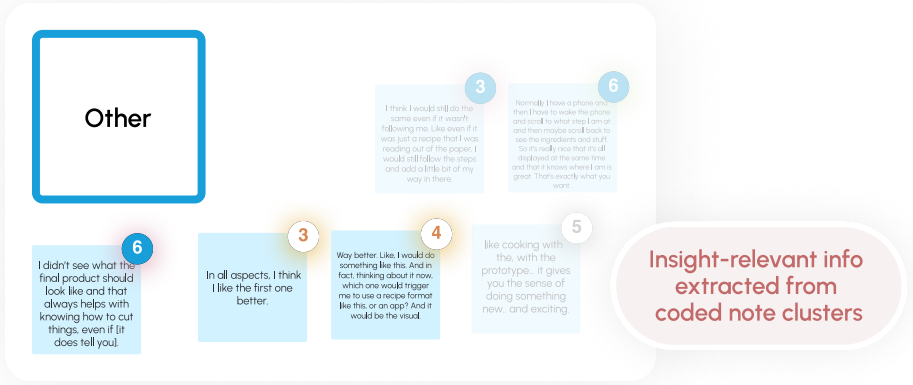


Figure 91. Comments on visuals from 'Other' cluster

02 Mixed-media Instructions Desired

Although all 6 participants preferred visuals in general, 4 of the 6 participants stated that they would prefer a combination of the familiar and experiential methods for receiving instructions. Participants 2, 5, and 6 would like to receive instructions verbally, textually, and with a video. They valued the ability to receive the instructions verbally as they did not have to look at their screen, they valued the video when they were unsure how to do a task, and they would appreciate having text under the video in case they missed or forgot the verbal instructions. The text would prevent them from having to ask the device to have to repeat itself. Participant 6 additionally expressed the desire to have an image of what the ingredient(s) should look like at the end of the task. This way they do not have to watch the entire video to see the end result. Participant 4 also expressed the desire to have textual captions underneath the video. However, they did not see the value of the verbal instructions as they found it difficult to cook and listen simultaneously.

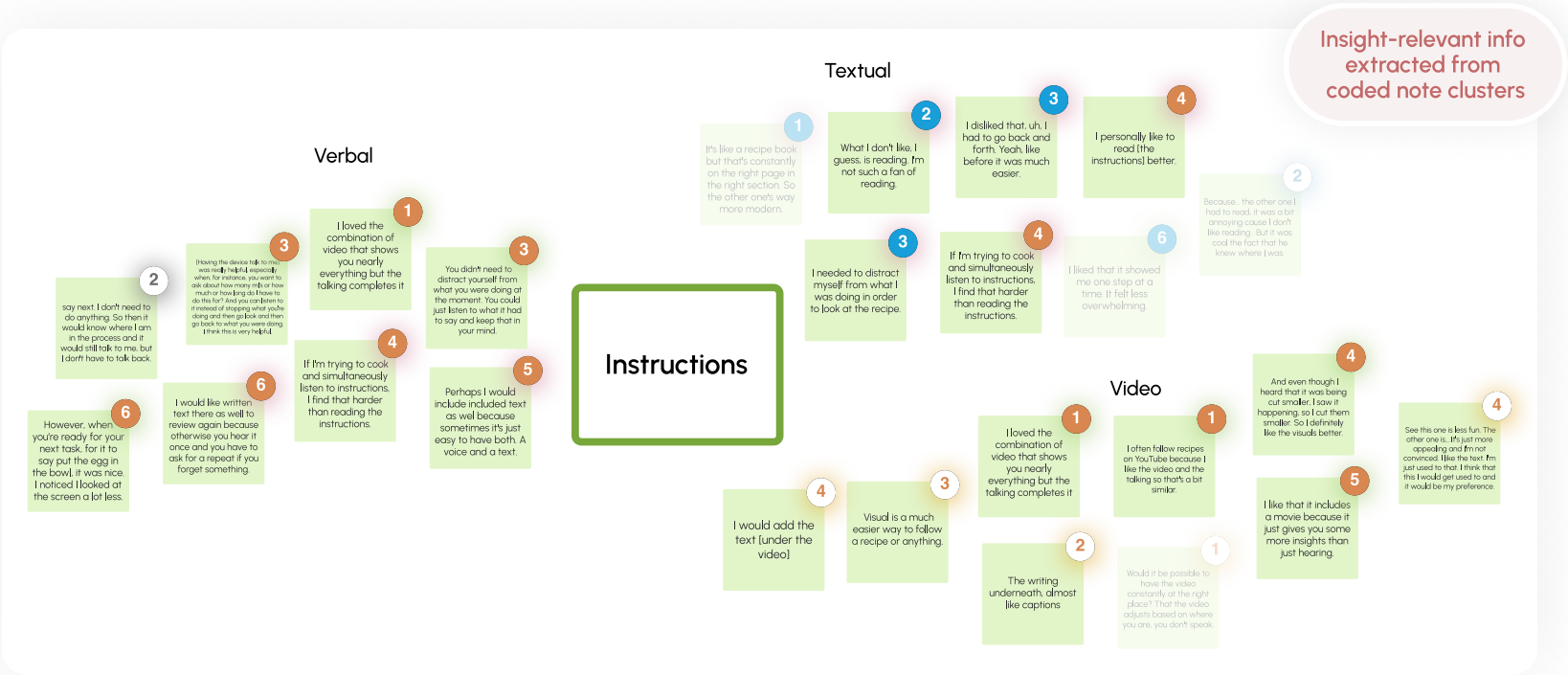


Figure 92. Comments on mixed-media instructions from the 'Instructions' cluster

03 Activity Recognition is Desirable

Activity recognition as a user-to-product communication method was the preference of 5 of the 6 participants. Only 1 participant expressed that they preferred speaking to the device instead because they found the activity recognition to be "slightly spooky". The rest expressed that it allowed them one less aspect they had to focus on. Participants 4 and 5 shared the opinion that the automation allowed them to focus better on other tasks. Participant 3 also preferred the automation, however, they had some concerns. They were unsure whether or not the technology would be capable of accurately recognizing their activities and stated that they trusted their ability to recognize when an ingredient needs attention (such as stirring an egg) more than the device.

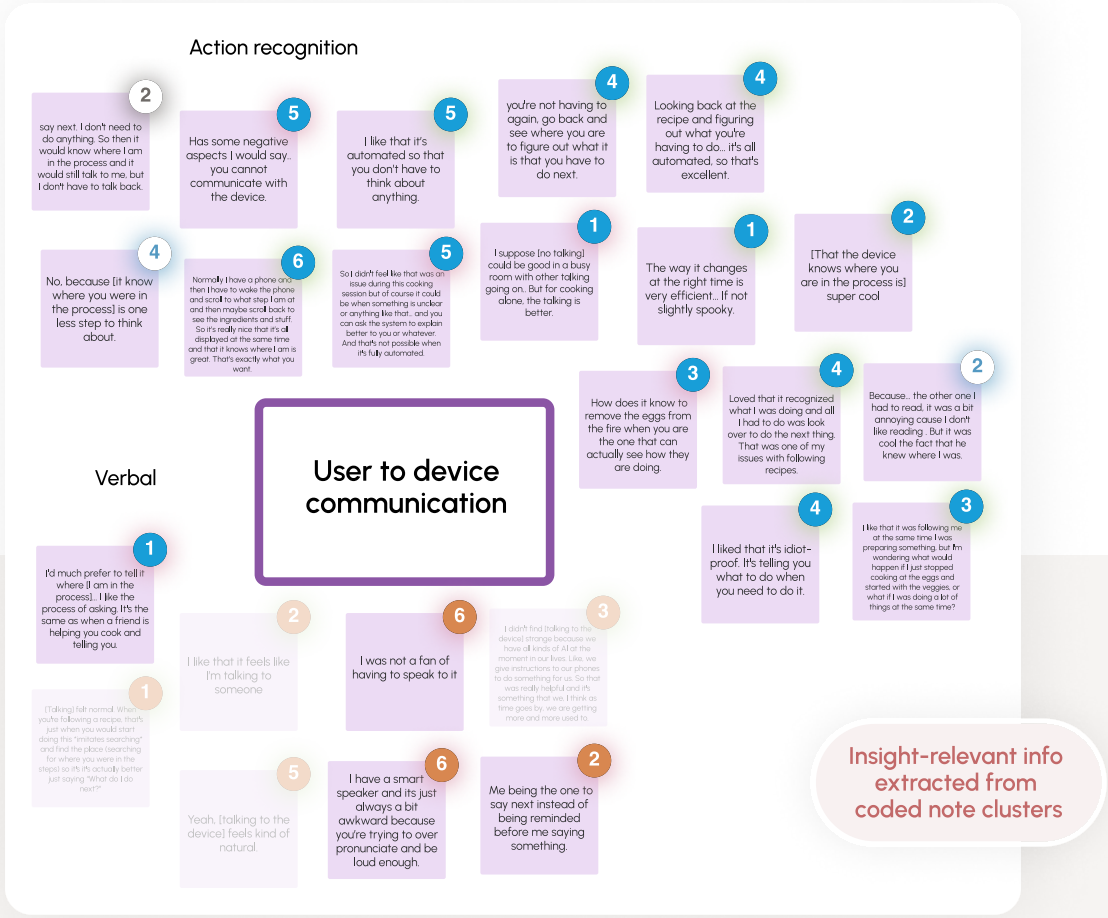


Figure 93. Comments on activity recognition from 'User to device communication' cluster

04 Desired Interruption Method

In general, all participants appreciated and valued the reminders such as when to stir the eggs. Participant 1 explained that the reminders were helpful because they would forget to check on ongoing tasks once they started doing something else. Participant 3 stated that they especially saw the value in reminders if there were many simultaneous tasks to manage at once. All 6 participants preferred the verbal reminders over the silent pop-up. Participants 1 and 4 explained that verbal reminders were preferred as it allowed them to not have to look at the screen. Participant 6 explicitly stated that they disliked the textual pop-up as it blocked the task instructions. They stated that they would prefer seeing the reminder and the instructions at the same time and not have any sections covered.

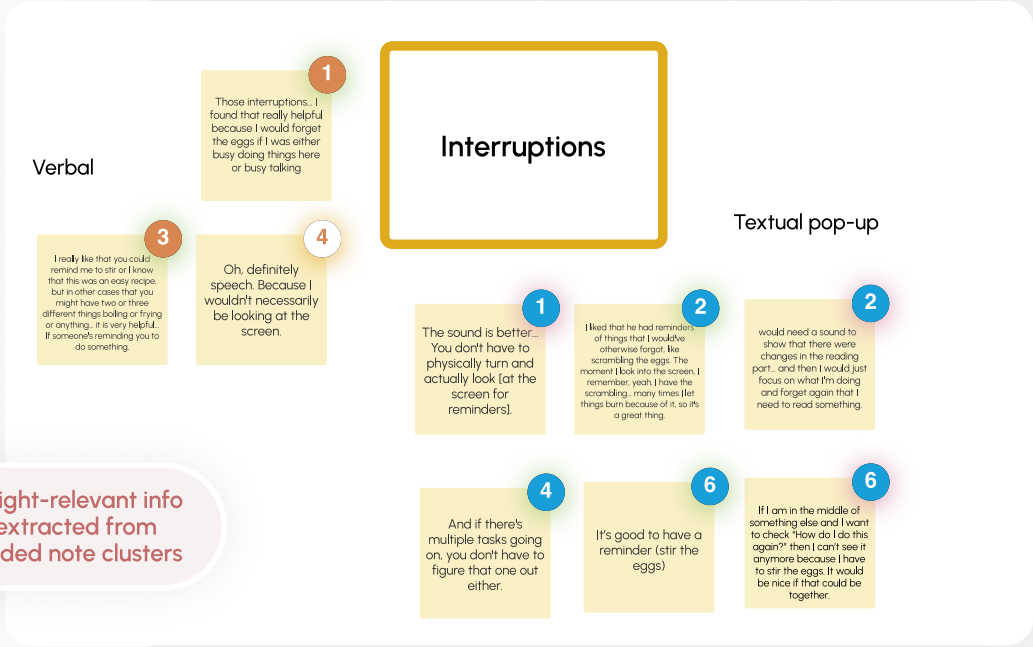


Figure 94. Comments on interruptions from 'Interruptions' cluster

05 Attention too Divided

1 2 3 4 5 6

5 of the 6 participants conveyed that their attention was too divided across the sections in the interface.

Participants 1, 4, and 5 experienced their attention being divided between the 'Current Task' and 'Ingredient' sections. They expressed the desire to have the ingredient amount in the 'Current Task' instruction section. It was assumed that having the ingredients and their amounts on same page as the instructions would provide an adequate overview and including them in the instructions would have been repetitive. However, these participants expressed that it was inconvenient to have to look left and right between the 'Current Task' and 'Ingredients' sections while carrying out a task. They expressed the desire to only need to direct their attention to one section.

Participants 1, 5, and 6 had their attention divided between the 'Current Task' and 'Timeline' sections. Participant 6 stated that they initially did not notice the task instructions as they were focused on the timeline. Participant 1 experienced the opposite; the instructions captured their attention, and they did not pay attention to the timeline. Participant 5 mentioned that they would appreciate seeing the next task they need to complete next to the current tasks instructions.

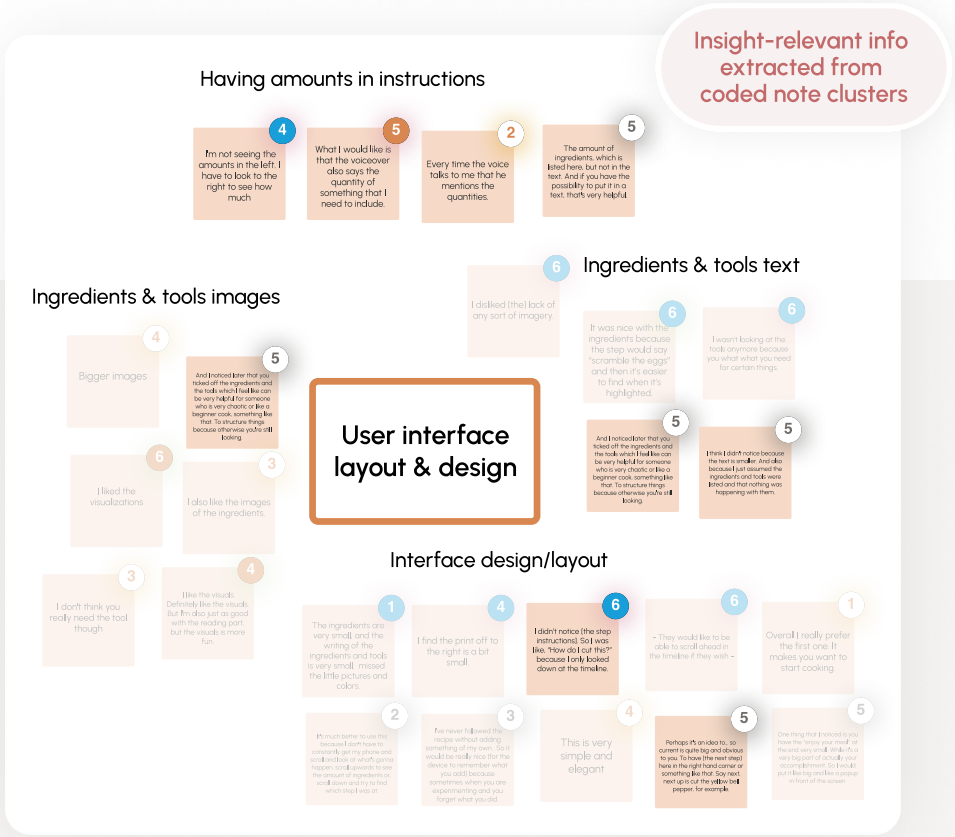


Figure 95. Comments on divided attention from the 'User interface layout & design' cluster

Design Insights Conclusion

In conclusion, participants prefer visual and verbal instructions because it is more fun and value the experiential interactions. However, several participants would like the instructions to be more time-saving by also including textual instructions and an image of what the ingredient should look like at the end of the task. Regarding user-to-product communication, participants prefer the efficiency of activity recognition over the experiential verbal communication. By combining interaction methods from both prototypes, users can have an experiential and efficient instruction-based cooking experience.

Additionally, participants saw great value in verbal reminders as it guaranteed that they would not miss a task but also did not fully interrupt their current task.

Lastly, the interface should be designed in a way that the user's attention is not unnecessarily divided between various sections.

Initial Design Brief Validation

The results from the analysis have initially validated that the design objectives from the Design Brief have been achieved. These results are separated into the Design Goal and the Interaction Vision.

Design Goal

01 The task overview, timing, reminders, and video instructions are described by the participants as lowering their cognitive overload while cooking

02 Verbal instructions and reminders allow the user to be minimally interrupted

03 Users valued how informative the prototypes are

Interaction Vision

01 Users feel as though a friend is helping them cook

01 Lowers Cognitive Load

4 of the 6 participants expressed that they experienced less cognitive load while cooking with the prototypes compared to cooking with traditional recipe instructions. Participant 1 and 2 stated that they felt as though they did not have to keep track of tasks and timing because the device did that for them. Participant 1 described this as more relaxing than cooking with traditional instruction methods. Participant 4 expressed that they did not have to determine where they must shift their attention to when multiple tasks were occurring at the same time. Lastly, participant 5 explained that the device lowered their cognitive load because they did not need to plan in advance, the product did it for them.

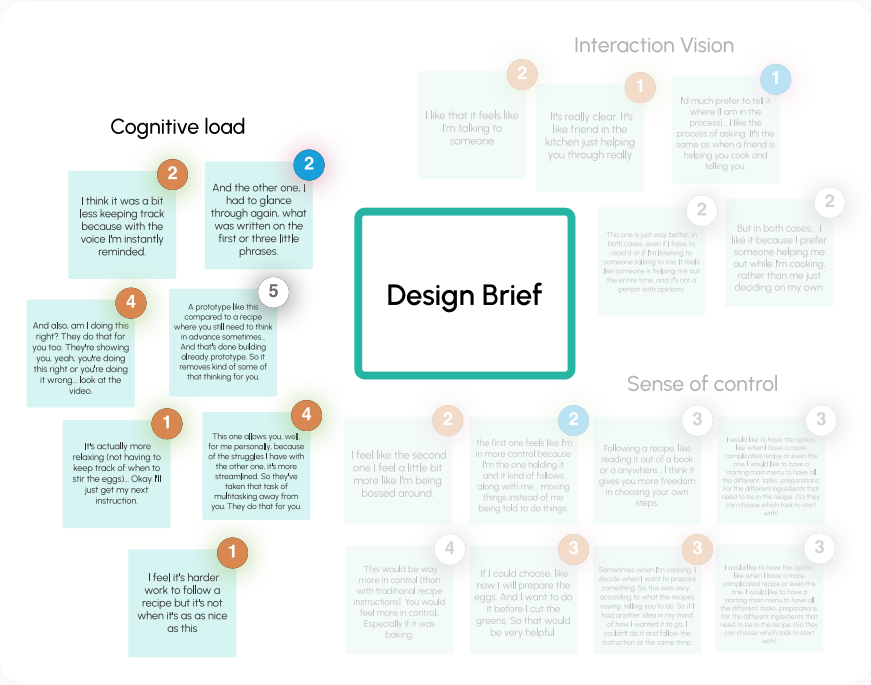


Figure 96. Comments on cognitive load from the 'Design Brief' cluster

02 Minimal Interruptions

The results from the 2nd and 4th Design Insights: Mixed-media Instructions and Desired Interruption Method exhibit that verbal information minimally interrupts the cooking flow. The user can hear and interpret the instructions and reminders without having to stop the task they are currently doing. Additionally, action recognition technology also allows for minimal interruptions as the user does not have to actively communicate with the device.

03 Information Overview

All 6 participants appreciated that all of the relevant information was displayed on one screen. Participant 2 and 6 both stated that the way the concepts display the information is much better than their current instruction methods as they do not have to constantly look at their phones and scroll back and forth between the ingredients and instructions. They expressed that it eliminated the issue of losing their place in the instructions. Participants also stated that they experienced the video instructions to be especially informative. Participant 4 voiced that they did not question whether or not they were doing a task correctly because the video assured them. Participant 5 stated that the video gave extra insights into how to do a task. However, participant 6 did mention missing the ability to scroll through the whole timeline to see the entire cooking process.

01 Friend Helping with Cooking

Participants 1 and 2 both expressed that they felt as though the device acted as a friend in the kitchen. This is similar to the interaction vision of having their Grandmother, a trusted companion, guide them through an unknown recipe. They conveyed that this was especially felt when the device was speaking to them as they cooked.

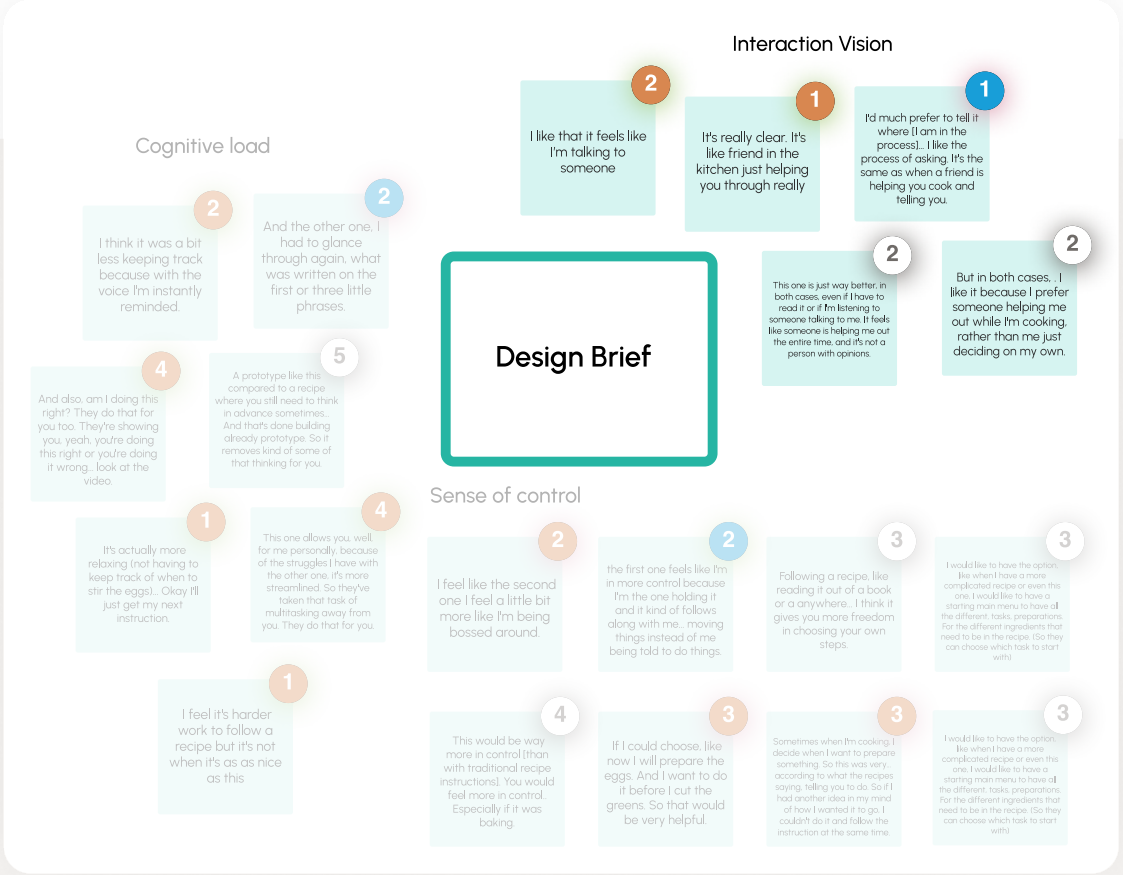


Figure 97. Comments on the impression of cooking with a friend from the 'Design Brief' cluster

Initial Design Brief Validation Conclusion

In conclusion, several participants expressed that they felt less cognitive load while cooking with the prototypes versus with traditional instruction methods. All 6 participants expressed that the verbal product-to-user communication allowed for minimal interruptions to the cooking flow. Moreover, all participants appreciated an informative overview of their cooking process. Regarding the interaction vision, 2 participants compared cooking with the device to having a friend help them with instructions.

These insights provide an initial exploratory glimpse into how the design solution satisfies the design brief. In order to further validate these findings, the final design proposal should be empirically tested with a larger sample size based on the Design Brief criteria.

Discussion

The following section discusses how the Concept Test was executed based on knowledge gained from the Context Research, how the researcher could have improved the tests, and whether the assumptions were correct. Finally, noteworthy suggestions from participants are discussed, that - for reasons elaborated on in this section - were not included in the final design proposal.

Enthusiastic About the Solution

Most of the participants were enthusiastic about the possibilities of an intended design solution. They expressed the desire to incorporate a solution into their cooking routines, and saw the value in the concepts. They expressed the desire for a hands-free solution and enjoyed that they did not have to scroll through the interface to gain the information they needed. Some participants expressed that they felt it reduced their cognitive load while cooking and made the experience more enjoyable. Future research should be carried out to further validate these insights.

Additionally, the participants appreciated that Human Activity Recognition and verbal instructions minimally interrupted the cooking flow. In conclusion, the participants felt that the concepts are heading in the correct direction of delivering an informative design solution that minimally interrupts the cooking workflow.

Adaptations from Context Research

The knowledge gained from the Context Research phase led to several adjustments in how the Concept Tests were executed. For example, the notes were converted into summarized quotes from the users instead of summarized messages. This allowed for the analysis to be more semantic as apposed to interpretive. This was chosen as the results should convey what the users specifically desire in a design.

Uncertainty Theme

The video instruction method seemed to alleviate many problems that were described in the Uncertainty theme from the Context Research. Many participants stated that they were not concerned about whether or not they were carrying out a task properly as the videos confirmed this. The Uncertainty theme was not the focus of the design solution space, yet seems to have been partially designed for in the process.

Assumptions

The textual aspect of the T&A prototype was assumed to be more familiar to users, as explained in the Conceptualization phase. Participants 1 and 4 both mentioned that textual instructions were indeed more familiar to them. However, participant 1 did not see this as a positive aspect. In fact, they described the T&A prototype as merely a recipe book that is always on the right page. Participant 4 was drawn to the familiarity of the textual prototype at first and described it as having their preference. However, they soon changed their mind once they were more familiar with the visual prototype. This could imply that participants are used to textual instructions, yet they are not the preferred instruction method; instead they are the most accessible. The enthusiasm over the instructional video expresses the desire for more experiential and visual instruction mediums. However, only participant 1 stated that they occasionally use recipe videos to follow instructions. They explained that they desire the visuals of the video yet find it harder work to follow a recipe and therefore often do not use one. They did not feel this was the case with the Visual & Verbal prototype. This implies that more visual instructions are desired yet the current methods are not user-friendly enough to always incorporate in their cooking routine.

Prototyping Decisions

The designer chose to omit currently available AI technology in the prototypes and instead decided to test using the Wizard of Oz (WoZ) technique. The WoZ technique is when the researcher (the Wizard) acts as the intelligence that would be incorporated in the prototype, during an experiment (Kelley 2018). For example, the researcher acted as the HAR technology, changed the prototype display as the cooking progressed, and verbally provided the users with instructions. However, the designer could have prerecorded the verbal instructions to simulate the absence of the researcher more accurately. This would have also allowed the researcher to observe more attentively during the cooking process, instead of reading the verbal instructions out to the participant. By observing more attentively, the researcher could have asked further questions after the session based on what was observed, such as why they rarely looked at the device. However, observations were still able to be made retrospectively via the video recordings which provided ample results.

Inaccurate User Journey

During the cooking session, it became apparent that immediately starting the cooking process by seeing the prototypes without any previous knowledge was not an accurate representation of how the cooking experience would actually be. In a real setting, users would search for a recipe, purchase the ingredients, then open the prototype when they were ready to start cooking. In the concept test, the participants had never seen the recipe before, or bought their own ingredients. Instead, they were presented with a prototype that displayed instructions with no context. Participant 6 mentioned that they would have liked the possibility to scroll through the entire timeline to get an overview of all the tasks. This may not have been the case if they had seen the recipe before the cooking began.

Retrospectively, the participants should have first been presented with the recipe on Swapmeals and asked to read the recipe title and glance over the ingredients to familiarize themselves. Once they felt as though they were ready to start cooking, the prototype should have been opened. This would be more in line with the intended interaction and would have limited the feelings of confusion when initially viewing the prototypes.

Participant Suggestions

An interesting improvement was suggested by participant 1. They mentioned that they would like for the instructional video speed to adjust to their cooking speed. Meaning that the video would always be at the stage where it is showing information that is relevant to what the user is doing at that moment. This is an intriguing improvement that should be further investigated to understand the logistics and technological requirements needed to realize it. Realizing this would provide the users with more accurate and targeted instructions that would prevent them from having to wait for the video to loop back around if they missed a technique. Therefore further minimizing interruptions to the workflow.

Another improvement was suggested by participant 3. They stated that they always adjust at least one component of a recipe and often forget what they had changed. They suggested that the device could remember the changes made for the next time they use the recipe. This suggestion connects to the 3rd theme from the Context Research, 'Adjusting Recipe to Fit Needs'. This theme was not part of the scope of this projected yet could be further explored in future projects.

07 Design

In this chapter, the design insights gathered from the Concept Tests have been utilized to create a design proposal. The design proposal is show-cased with user interface frames, a usage scenario, and the technology options that could be used to realize the product.

Design Criteria

The design proposal should conform to the Design Brief and the requirements uncovered in the Context Research, Current Solutions, & Conceptualization phases as well as the insights generated from the Concept Testing phase.

Context Research, Current Solutions, & Conceptualization phase Requirements

01 Timeline overview of all steps

02 Approximate time to complete task

03 Relationship between tasks (dependent/independent)

04 Ingredients & their amounts

05 Ingredients that are split between steps

06 Choice of which task to do next

07 Completed tasks

08 Upcoming tasks

09 Passive & active tasks

10 Timers & reminders

Design Insight Requirements from Concept Tests

11 Task overview, ingredients, and tools are displayed visually

12 User-to-device communication is action-based

13 Interruptions are verbal with non-obstructive visual cues

14 Instructions are delivered verbally in addition to video and text

15 The user's attention is minimally divided across the interface

16 Quantities are included in the instructions

17 There is an example of the end result of a task

Design Brief Requirements

18 Hands-free

19 Non-linear

20 Informative

21 Minimally interrupts cooking flow

22 Reduces cognitive load & negative emotions

23 Feels as though they are being guided by their Grandmother

Design Proposal

Frames of the design proposal have been created in Figma. Figure 98 shows examples of the design proposal at various stages of the cooking process. Note that some frames show differing recipes in order to display all of the features.

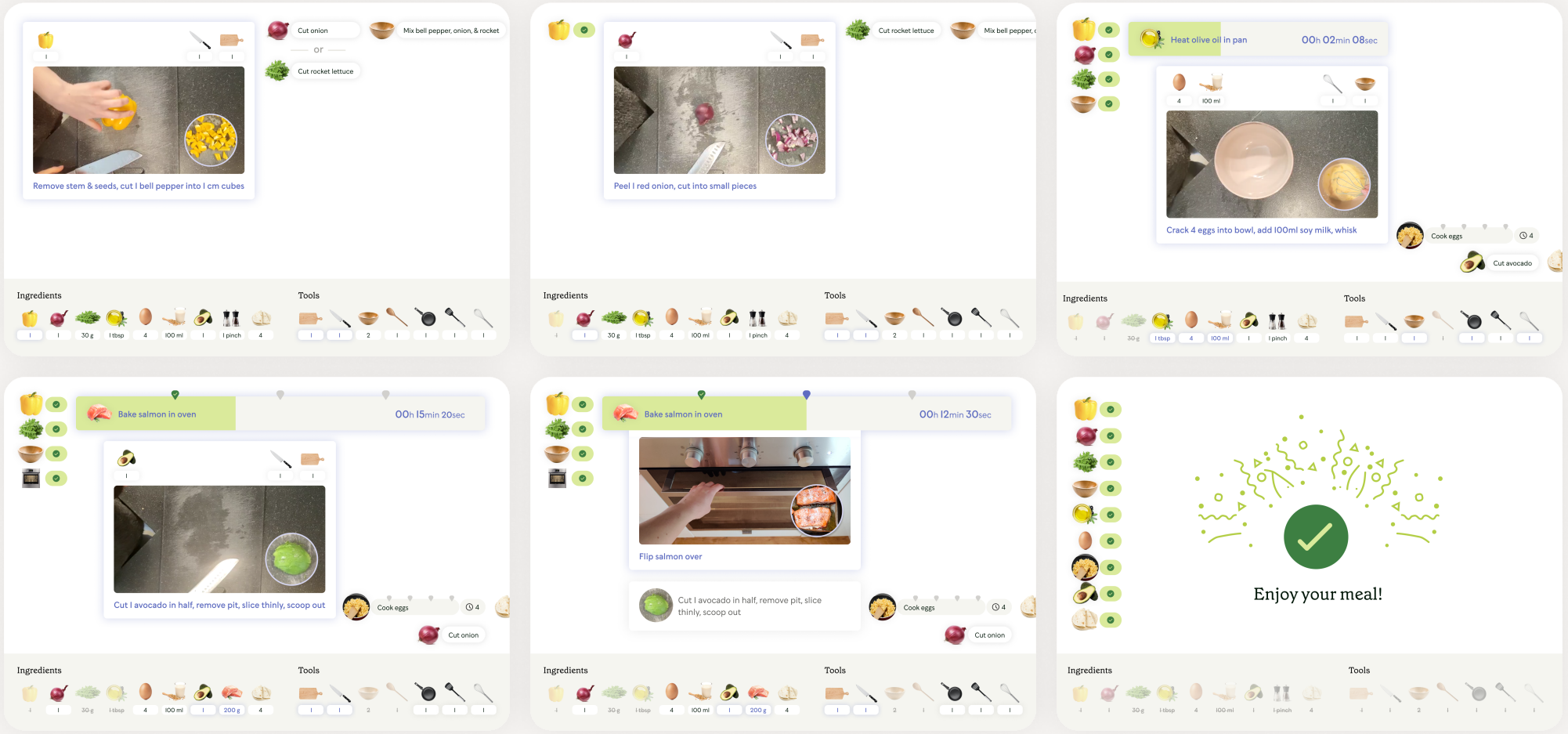


Figure 98. Frames of proposed design at various stages of the cooking process



Figure 99. Frame of design proposal

The design proposal incorporates all the requirements outlined in the Design Criteria. Figures 99-105 and accompanied numbering display where the requirements can be found in the interface. The tasks are still displayed in a timeline overview (1), however, now the current task instructions are also within this timeline. This allows the user's attention to be directed at one area and provide a clearer indication of where they are in the timeline (15). The instructions are now delivered with verbal, video, and textual instructions (14). The textual instructions have been included below the video as captions. The ingredient and its quantity as well as the tools have been included in the instructional component as well as in the textual instructions (16). This prevents the user from having to search for the amount elsewhere. The user can still have a complete overview of all the instructions and tools at the bottom of the screen (4). These have been shifted from the top to the bottom as they are not as crucial as the timeline and instructions. The user can see if they have a choice between 2 tasks by stacking them vertically with "or" in between (6), making non-linear cooking possible. The user is able to communicate to the device which task they would like to do next by grabbing the desired ingredient. The device recognizes the task and the timeline adjusts to their choice.

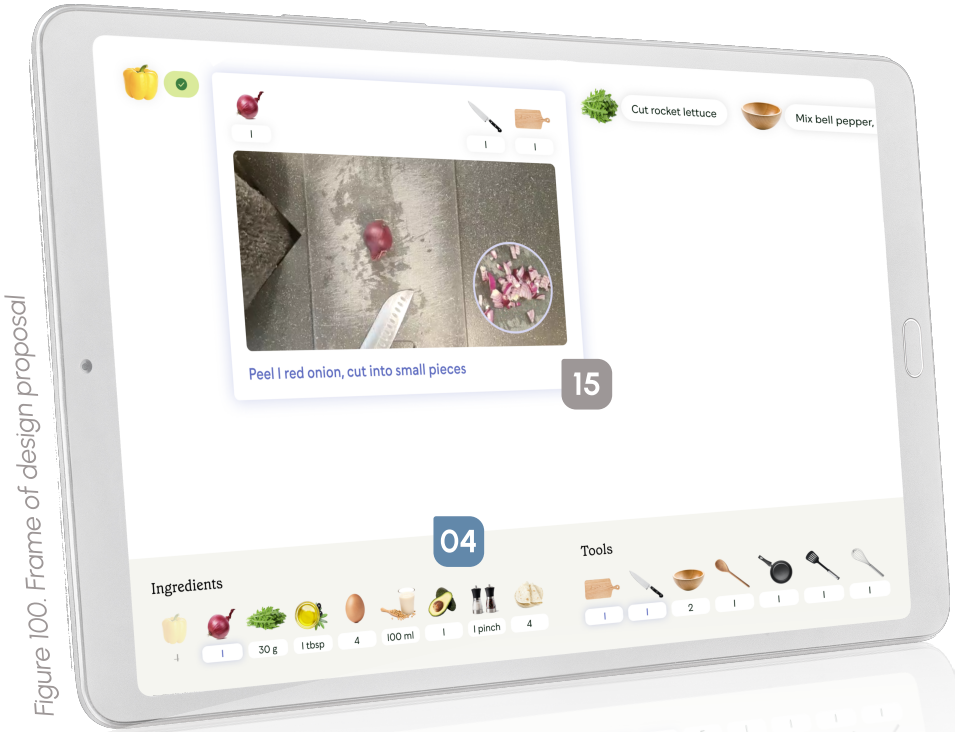


Figure 100. Frame of design proposal

The time the tasks take to complete has been removed from tasks where the time varies greatly per home-cook. Solely the tasks where the time estimation is more accurate, such as heating oil or baking salmon in the oven are now shown. This is because providing an accurate time estimate for the other tasks is unattainable as it varies for every home-cook and therefore the information is futile to the user. The time was originally incorporated because participant 2 from the Context Research stated that they would like to know the approximate time of tasks so that they could time the steps accordingly. With the design proposal, timing does not need to be done by the users, as the device reminds the user when to carry out tasks, and therefore the time estimates are no longer necessary. Time that is precise can be seen next to upcoming tasks (2a) or as a timer in current tasks (2b). The way in which dependent and independent tasks are portrayed has been unchanged: vertically stacked means the tasks do not need to be completed in any particular order and horizontally placed means the first task has to occur before the second one. Figure 101 (3) shows that the avocados can be cut at the same time the eggs are cooking, yet the ingredients can not be added to the wraps until both tasks are finished. Completed tasks are now vertically assembled to the left of the interface (7). This is so that the information is not lost as the timeline moves. This provides a complete overview of how far in the process the user is as well as attempting to provide a sense of accomplishment, in order to reduce negative emotions. Upcoming tasks are still shown to the right of the current task (8). If an ingredient is split between 2 tasks, this is shown by fading out the portion of the ingredient that is not used and explaining in the instructions (5).



Figure 101. Frame of design proposal

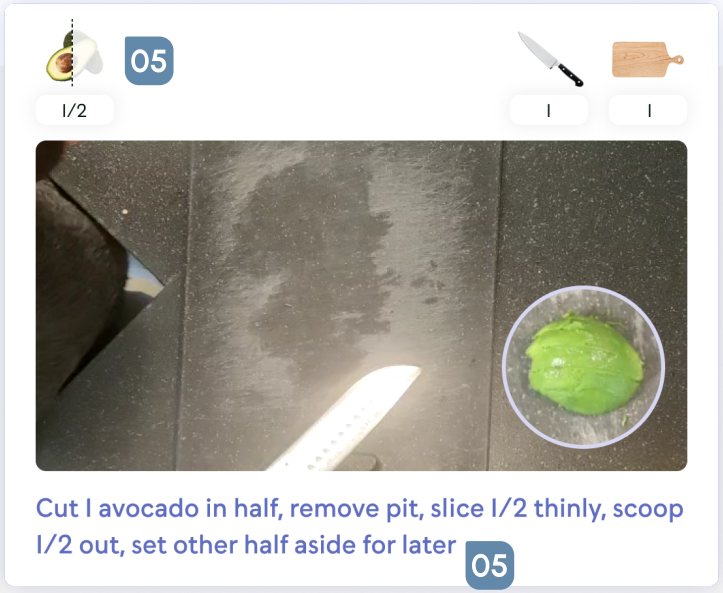


Figure 102. Zoomed in frame of instructions box to show that the user needs to use half an avocado



Figure 103. Frame of design proposal

Passive and active tasks are displayed in the same way as before, namely, a grey fill for passive tasks and a white fill with a drop-shadow for active tasks (9). Passive tasks contain time estimates which change to timers if the task is currently occurring. Some passive tasks contain active moments, such as flipping over the salmon. The active moments are shown with arrows pointing at the instance when the action should occur. If the action has not occurred yet, the arrow is grey. If the action has already occurred, the arrow is green with a check-mark. Lastly, if the task needs to happen right now, the arrow is purple (10) and a reminder appears (13). The reminder instructions are delivered verbally, with a video, and textual instructions (13). The task that it is interrupting decreases in size, the video is temporarily removed, and the instructions change from blue (active) to grey text. The task is therefore still visible yet is visually shown to have a lower priority over the reminder. The image in the bottom right corner of the video is a visual representation of how the ingredient(s) should look once the task has been completed (17). This was requested so that users do not have to watch the complete video if unnecessary. Ingredients, tools, and tasks are all displayed with visual representations as requested in the concept tests (11).

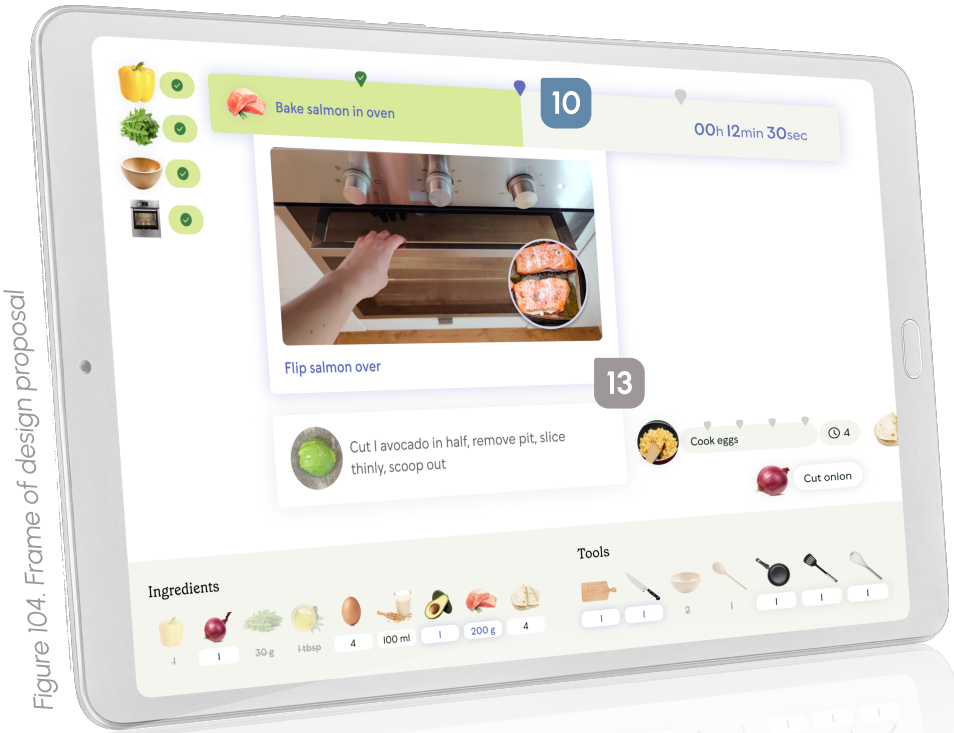


Figure 104. Frame of design proposal



Figure 105. Frame of design proposal

Users can communicate where they are in the cooking process simply by switching tasks. This also applies when the user has the choice between 2 or more tasks of what to do next. When the home-cook has finished making the recipe, they receive a confirmation message telling them to enjoy their meal (figure 105).

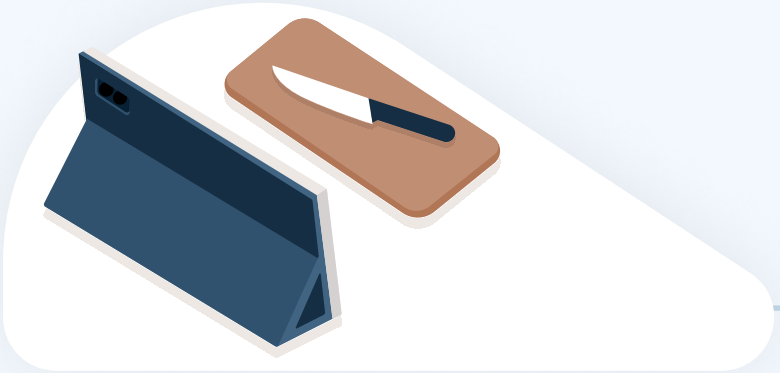
Usage Scenario

The usage scenario shows how the design proposal should be used.

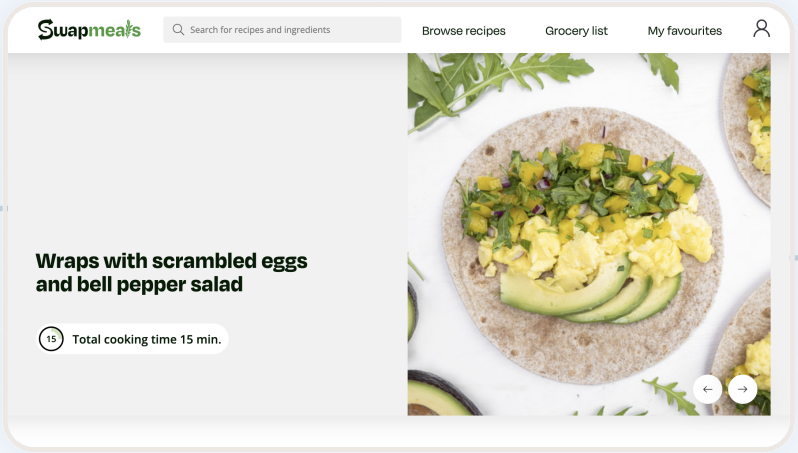


User

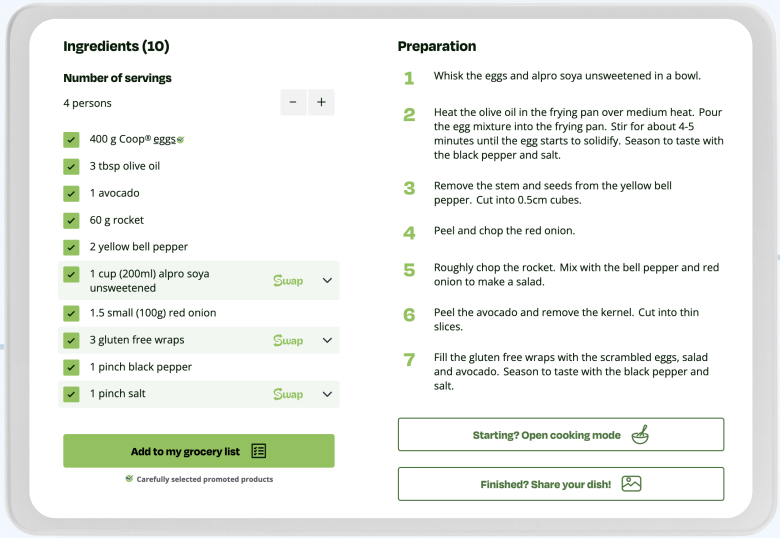
Samantha has just moved out of her parents house and is learning to cook for herself for the first time. She cooks for herself and her roommates around 2 times per week. She describes herself as a Curious Cook and Balance Seeker.



01 Samantha sets up her tablet to face her cooking area.

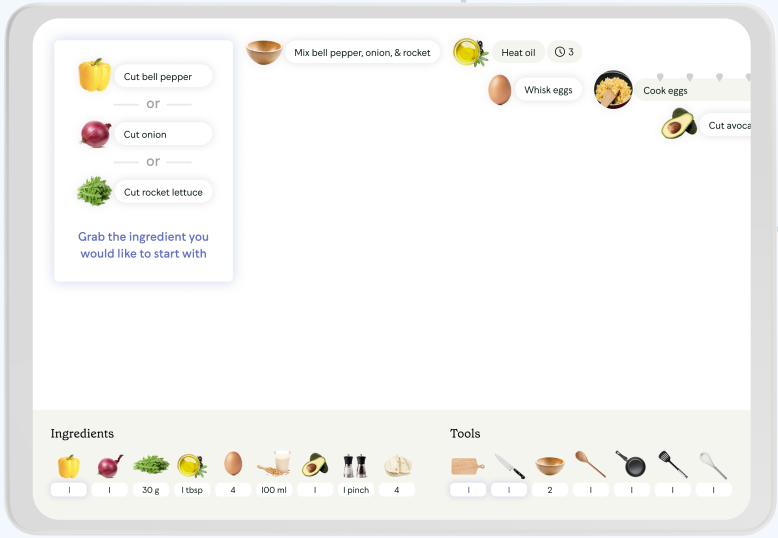


02 Samantha opens up the Swapmeals recipe she wants to eat.

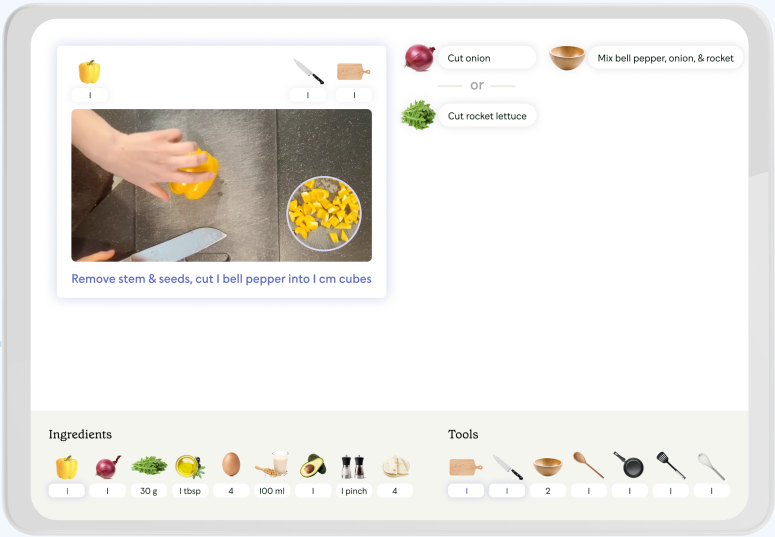


03 Samantha scrolls down to the preparation section and presses on the "Open cooking mode button".

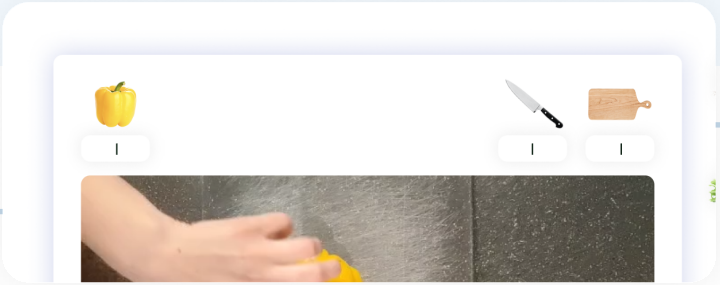
Usage Scenario



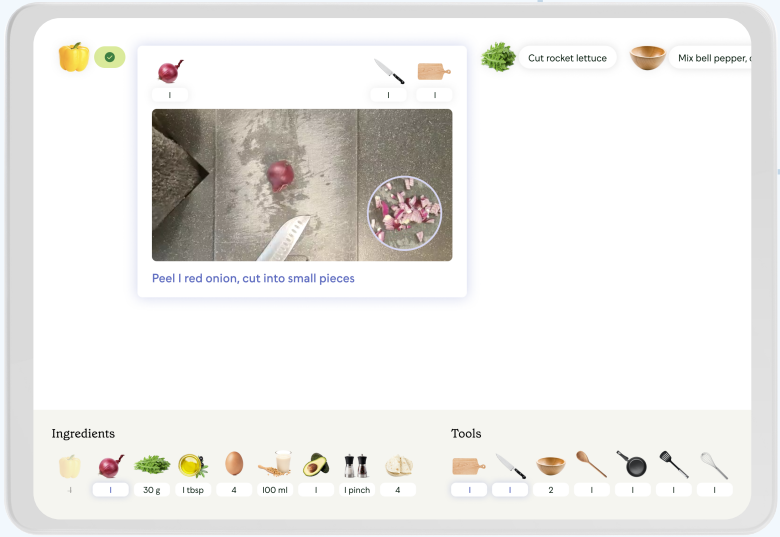
04 "Open cooking mode" opens the design proposal. Samantha can choose which task she would like to start with from 3 options.



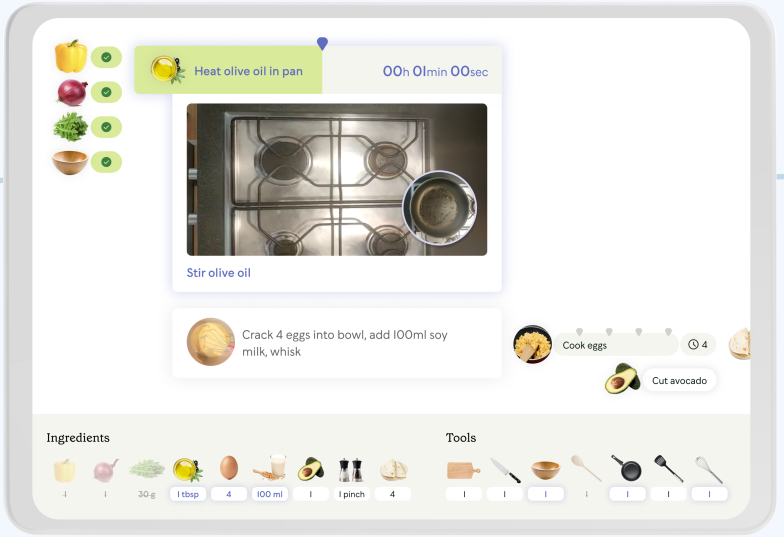
05 Samantha grabs the yellow bell pepper, letting the device know that is the task she would like to start with so it can provide her the instructions.



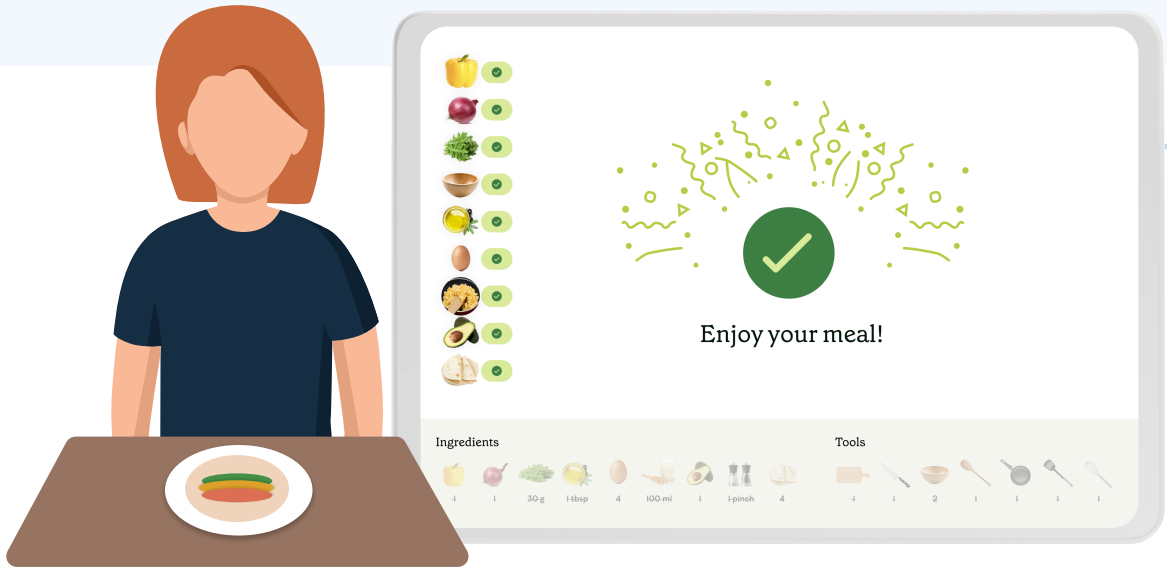
06 Samantha can see the ingredients & tools needed for the task above the instructions. Therefore, not having to scroll between the instructions and the item lists which allows her to fully focus on cooking.



07 Samantha has finished cutting the bell pepper, so she reaches for the next ingredient she would like to prepare. The device gives her the corresponding instructions.



08 While Samantha is busy preparing the eggs, the olive oil on the stove needs stirring. The device verbally reminds her and highlights the new action.





09 Samantha follows all steps until she is done and can enjoy her home-cooked meal!

Required Technology

The 2 main technological aspects that need to be realized to develop this design proposal are flexible recipe components and Human Activity Recognition. Verdify's engineers are currently exploring several approaches that allow for flexible components in order to improve their advanced swapping possibilities. HAR is an unexplored technology for the company.

Flexible Recipe Components

In order to realize the design proposal, the task components within a recipe need to exist independently from the recipe text in order to be able to shift places within the timeline, when necessary. If the tasks do not exist on their own, then the recipe instructions are forced to remain linear. Additionally, the design proposal adjusts based on the users actions and relays this information visually. For example, if salmon is being baked in the oven for 20 minutes and the user is suggested 3 tasks to complete in the meantime, then the salmon component would stretch across the length of the 3 task components. If the user is able to complete 4 tasks in that amount of time, then the salmon component would increase in size to visually represent the new end time (at the end of the 4th task).

Verdify is currently researching technological developments that would allow recipe tasks to exist independently, in order to enhance their ingredient swapping options that they currently provide their users. The following section briefly explains the research they are carrying out that is needed to realize the design proposal. The information is provided by Verdify's software and AI engineer.

Verdify is currently using natural language processing (NLP), named entity recognition (NER), and regex string matching in order create an application that is able to take recipe text and generate it into ingredient & equipment lists. These lists are connected to simplified instruction steps which are then linked in succession. This means that Verdify is able to take recipe data and turn it into recipe instructions. With this information, they are able to change it, restructure it, and extend it, to a certain degree. Swapmeals uses this to allow its users to swap ingredients out for other ingredients if a user does not like a food, has an allergy, etc.

They are currently researching ways in which they can provide their users with even more complex replacement possibilities by overcoming the challenge of reasoning about the relationships between ingredients, instructions, and equipment. Swapping an ingredient out for another can have strong effects on the preparation methods and time of the recipe. The user may have to use different tools and cooking times may change depending on the replacement. Some of this information is not available in the recipe text but is needed to provide the correct new instructions to the user. In order to allow for this, the information must be generated from data that does not explicitly exist in the current recipe text. People often rely on information that exists implicitly, through personal or instinctual knowledge. This implied knowledge is apparent through the context of the recipe. For example, the user needs to turn on the stove before heating the oil despite the fact that the recipe instructions only say to heat the oil. This knowledge is not accessible to computers by default and therefore has to be formalized in order to draw connections between what the text says and what it means.

Verdify is currently exploring models and theories that allow the variables to be flexible and be able to reason this implied knowledge. They have began structuring a graph-based recipe parser that relates entities to each other and deduces some implied actions. They are in contact with other researchers that are also exploring this technology. They intend to turn their efforts into a set of tools that can be used to realize their goal of improving their personalized nutrition options within in the near future.

Human Activity Recognition Technology

The raw data needed to identify human activities is often collected from one or more sensors, such as microphones, ultrasonic sensors, RBG cameras, and infrared imaging (Fu et al, 2020). The design proposal aims to not necessitate the installment of external sensors and therefore the sensors used for the HAR should exist within the user's device. As an example, the iPad 10.2 contains the following sensors (Apple, 2023, iPad):

01 Camera & front camera

02 Touch ID *(fingerprint recognition)*

03 Three axis gyro *(measures rotation of device)*

04 Accelerometer *(detects orientation of device)*

05 Barometer *(measures pressure differences)*

06 Ambient light sensor *(detects light to dim screen)*

07 Microphones

There are many papers on detecting human activity with built-in accelerometers, where the device stays on-person. However, utilizing this sensor does not allow for recognizing complex and real-time human activities (Wan et al., 2020). Making use of the camera built into the user's device, for a vision-based HAR approach proves to be more affective in recognizing complex user activities (Poulouse et al., 2022). Built-in microphones are also able to gather sounds that are relevant in detecting human activities (Yuan, 2019). These methods, in combination, seem to be the most reasonable approaches in accurately recognizing activities for the purpose of this project. The camera can detect shapes, colours (Lei et al., 2012), and poses (Fu et al., 2020). While microphones can be used to detect relevant sounds such as blending, frying, etc.

There are several databases that can detect the cooking activities from gathered raw data. The datasets can detect activities by using multiple sensors such as the CMU-MMAC (Torre & Hodgins, 2009) dataset which contains both video and audio data. Databases can also only contain 1 sensor such as the MPII Cooking Activity Dataset (Rohrbach, 2012). While vision and audio data is the most accurate in fine-grained HAR, it does lack privacy protection (Poulouse, 2022). Therefore, it is only a feasible approach for users that have minimal privacy concerns. Additionally, the camera needs to be able to be positioned in a location where it can see the user clearly. Further research should determine if this is realistic in the cooking context and if there are other ways the home-cooks activities could be identified that are less invasive.

In conclusion, Human Activity Recognition using built-in camera and microphones is a promising approach for detecting complex cooking activities. However, the solution lacks privacy protection which may be a concern for users and future research should validate if HAR is feasible in the kitchen context.

Feasibility Demonstrations

To convey the feasibility of the technology in the context of this project, several demonstrations (images, audio, & poses) of how the technology operates were created using Teachable Machine. Teachable Machine is a web-based tool that allows users to create machine learning models easily and quickly (Teachable Machine, n.d.). These models provide a basic impression of how the technology works; deeper models are outside the scope of this project.

Image Demonstration

In order to have the tool recognize the difference between a bell pepper that is being cut and one that has been cut, various images were provided. If the bell pepper is being cut, the user should either be holding the pepper and/or holding the knife. If the user has put down either item and the bell pepper is no longer whole, then the model assumes that the user is finished with that task (see figure 106).

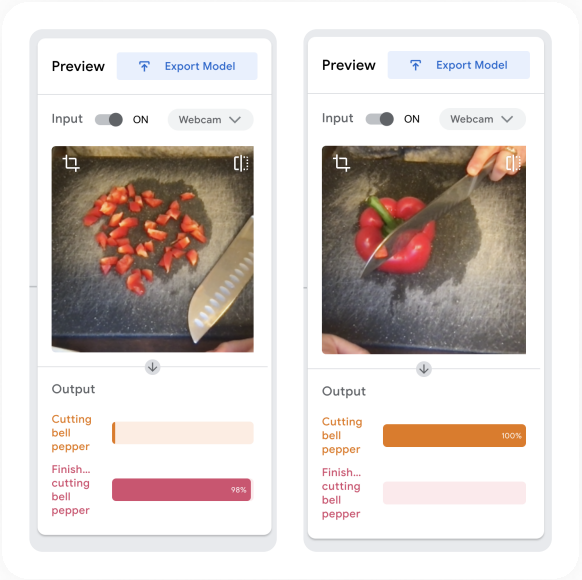


Figure 106. Teachable Machine image model to detect the difference between a user actively cutting a bell pepper and a user being finished cutting a bell pepper

Audio Demonstration

The audio model was trained to detect the difference between the sound of ingredients that are being cut and the sound of ingredients that are frying on the stove. The model contains a background noise class in order to disregard irrelevant noises and only identify relevant sounds.



Figure 107. Teachable Machine audio model that detects the difference ingredients being cut (a) and ingredients being fried (b)

Pose Demonstration

The pose model demonstration uses body positioning to detect when an ingredient is being cut and when an ingredient is being stirred on the stove. If the home-cooks arm moves up and down then the model determines that they are cutting whereas if their arm moves in a circular motion, then it identifies this as stirring.

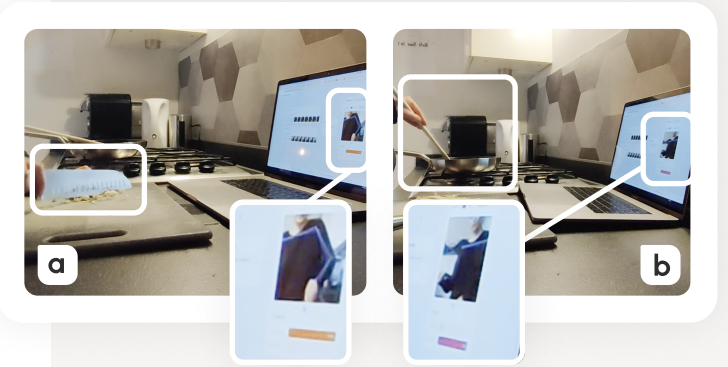


Figure 108. Teachable Machine pose model that detects the difference ingredients being cut (a) and ingredients being stirred (b)

Discussion

To summarize, the design proposal needs Human Activity Recognition technology and flexible task components in order for it to be realized. The feasibility of using HAR technology in the near future is promising, yet research into privacy concerns and feasibility tests need to take place in order to validate its suitability for user-to-product communication. Regarding allowing for flexible task components, Verdify is currently exploring ways to realize this and aims to have this available in the near future. However, both technological aspects are not yet readily available. In order for Verdify to create a minimal viable product (MVP) before this technology is available, a few adjustments could be made to the design.

Instead of allowing the user to choose which task they would like to do next, the steps could be provided in a set order. This would mean the users would lose some of the autonomy that the design proposal provides but would still be able to adjust the step order themselves if desired. They would have to jump between steps as they would using a traditional recipe instruction method.

Regarding user-to-product communication, Verdify could explore methods that are already being used in currently available products such as voice commands and/or the hand gesture technology that Mealime uses (Mealime, 2019, *How to use cooking mode*). While it is not the desired method as the user still has to interrupt their task at hand in order to communicate with their hands, it is still an improvement from actually touching the screen as the user would not dirty their device.

08 Final Remarks

This final chapter includes recommendations for further developments of the project, a conclusion of the project, and lastly a personal reflection from the author.

Recommendations

The following recommendations regard future research to strengthen the design solution as well as weak areas of the design that should be developed further.

Interface Recommendations

01 A complete user flow diagram should be created

The current design solution deliverable provides a glimpse into how the user interface should look and operate. However, in order for the product to be developed, a complete user flow diagram of all interaction moments needs to be mapped out. Additionally, a complete prototype would also help in communicating the concept's functionality to developers. Figure 109 provides an example of a user flow diagram.

02 How the interface looks in less than ideal scenarios should be designed for and elaborated on

The proposed design portrays a recipe where the ingredients & tools fit nicely on the screen, the overview of tasks does not extend past the borders, and there are no outlier situations. Other recipes may contain many more ingredients or a multitude of options regarding which task to do next. How the interface appears in these situations needs to be explored and described. An initial suggestion regarding surplus ingredients could be to have the excess ingredients fade out and appear as they are needed, with other ingredients having been crossed off.

03 The final design interface should be validated with users

The final design proposal has been created with the input from end-users, however, the proposal itself has not been tested and verified with users. An additional user test should be carried out to verify that the users needs and visions have been sufficiently incorporate in the proposal. One test should assess the usability of the interface. Another user test should compare the cognitive load experienced using traditional instructions methods versus the design solution, in order to validate this aspect of the design goal.

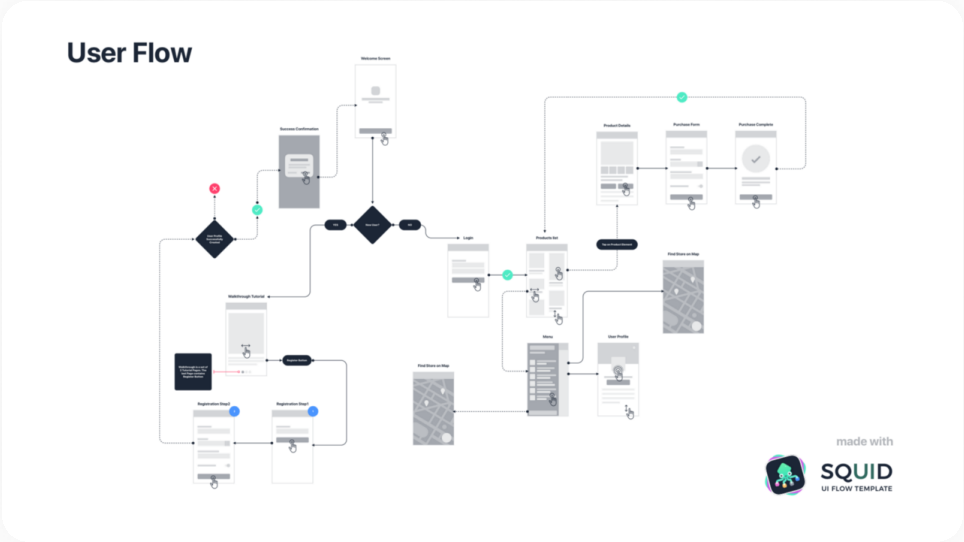


Figure 109. Example of a user flow diagram from https://blog.prototypr.io/ux-flows-and-why-theyre-so-confusing-26670b9089d4

04 Explore where the instruction videos and ingredient images can be extracted from

The instructional videos and the images of the ingredients need to be gathered from a source. The videos could be recorded and collected manually, however this would cost a great deal of time. Ideally they would come from an existing database. An appropriate source should be investigated and identified.

05 Explore creating the interface on a smartphone

The design proposal has been built on a tablet to allow the space to create an ideal solution to following recipe instructions. However, ways in which the interface could be adapted to fit on a smartphone could be explored in order to make the product more accessible.

Research Recommendations

06 Research to validate tablet HAR feasibility

The next suggestion is to test the feasibility of Human Activity Recognition using a tablet or laptop in the kitchen. The test should assess the accuracy of action recognition and uncover how realistic it is to track the users actions with one camera and microphone. The test should explore if the user is adequately in view and if the task sounds can be accurately detected and identified. The exploration should also investigate which database identifies and labels activities the most accurately. Lastly, the users view on privacy should be evaluated. HAR through cameras and microphones lacks privacy protection, thus research should be done into understanding if this is a concern for the intended users.

07 Research to explore device personality

An additional recommendation would be to explore the personality type that the product should embrace. The concept testing between the Text & Action-based prototype and the Visual & Verbal prototype explored personality difference on the surface-level. The T&A prototype could be described as shy and serious while the V&V prototype is more playful and out-going. The V&V prototype was preferred overall, yet the personality can be explored in much more depth. A suggestion would be to explore which personality traits users would value in the prototype. These personality traits can be expressed in the verbal and written language, verbal tone-of-voice, and delivery of information. One study identified 7 personality traits and proved that voice interaction with a creative, sincere, and intelligently perceived voice assistant increases the participants sense of control and caused them to be more engaged in voice assistant interactions (Poushneh, 2021). Similar research in the context of instruction-based cooking should be carried out in order to uncover which personality traits would aid the interface in further reducing feelings of cognitive overload as well as achieve the interaction vision of cooking with a trusted party.

08 Explore if having the instructional video harmonize with the users progress is feasible

One participant from the Concept Test mentioned that they would benefit from having the instruction video coordinate with where they are in the task process. This would prevent them from having to wait for the video to loop back to the section that is relevant to them. Future research could explore how this feature could be realistically implemented as it has the potential to improve the user experience.

Project Conclusion

Home-cooks often face cognitive overload while cooking due to frequently switching their attention between tasks, managing timing of actions, and interrupting their process in order to interact with their recipe instructions. A design solution has been proposed and acts as a starting point for the further research and development of a product that delivers cooking instructions in a hands-free, non-linear, and informative manner. The proposal has the potential to minimally interrupt the cooking flow, reduce cognitive overload associated with cooking, and make cooking new recipes more similar to cooking familiar recipes. The design solution serves as an example of how Artificial Intelligence can be used to enhance daily activities through design. The concept acts as the bridge between new technology opportunities and user needs.

The project has utilized a User-centered Design approach to deliver an innovative design solution that is in accordance with user needs. Technological and societal limitations were reduced in order to uncover what the ideal design solution would be for users. However, the proposed design is assumed to be feasible within 5 years due to current technological advancements. Provisionally, Verdify could develop a minimal viable product by utilizing gesture recognition technology, such as used in Mealime's cooking mode. Although this adjustment sacrifices the optimal user experience, it is suggested as a temporary solution as it would allow the product to be presently feasible. Participants expressed enthusiasm for the intended solution, however, the final design has not been validated with users. Further tests should be executed with a high-fidelity prototype in order to verify the design decisions made in the Design phase. Technical specifications also need to be investigated and indicated in order to realize the concept. Time limitations prevented the ability to dive into the product's personality which is a crucial aspect of the user experience regarding interacting with the device. Future research should explore desired personality traits for the product.

In conclusion, the design solution is a promising initial step in improving the instruction-based cooking experience for home-cooks.

Personal Reflection

When I began this project, I had a general idea of the end result, yet I underestimated how challenging it would be to get there. This project is the first time I have executed a design project individually of this scale, as I (uncommonly) completed my Bachelor End Project in a group. It has proven to be the most challenging project in my academic career. I had to manage which direction the project would head in and which aspects I would be focusing on in the scope of the project. I entered this project with the intention to understand users needs, explore Artificial Intelligence opportunities through design, explore incorporating suitable personality traits in a design solution, and to create a high-fidelity prototype in order to execute user tests. My supervisory team informed me that I may have to scale back, yet I held on to the notion for as long as I could. This is a challenge that I have faced in previous projects as I get overly enthusiastic and sometimes lose touch with the bigger picture and what is feasible.

Despite all the challenges, this project has been the most inspiring project I have completed and the one I take the most pride in. I have learned a great deal through the course of the project and have been able to to showcase much of what I have learned from my Bachelor and Master studies. I have been able to pull knowledge and techniques that I have previously learned into this project that have gone unused for some time.

This project has allowed me to learn a good deal of what work is occurring now in regard to smart solutions for cooking, the types of Artificial Intelligence technology, and the advancements of Human Activity Recognition. It has been inspiring to read about how these technologies can enrich our lives and assist users that are in need. It has been fascinating to learn about how HAR can allow elderly people to live independently for longer. This project has further confirmed my passion for using design to enhance daily activities, by being the bridge between technological opportunities and user needs.

Looking back at it now while writing these final words, I am very proud of what this project has become and what I have delivered.

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10 Appendix

The appendix contains additional information that explains certain parts of the project with more detail.

Appendix A: Project Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME
Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Fenwick 5898
initials: KV given name: Kayla Valerie
student number: [redacted]
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): ( ) IPD (★) DfI ( ) SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign ( ) Tech. in Sustainable Design ( ) Entrepeneurship

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Marco Rozendaal dept. / section: HICD
** mentor: Christina Schneegass dept. / section: HICD
2nd mentor: Fleur Pasman
organisation: Verdify
city: Wageningen country: Netherlands

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

comments (optional): Marco's expertise in Interaction Design and AI and Christina's expertise in Human-Computer relationships are both valuable to the project, and cover different areas of the field, that was difficult to find in other departments.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

chair Marco Rozendaal date 06 - 09 - 2022 signature [redacted]

CHECK STUDY PROGRESS
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 27 EC
Of which, taking the conditional requirements into account, can be part of the exam programme 27 EC
List of electives obtained before the third semester without approval of the BoE

(★) YES all 1st year master courses passed
( ) NO missing 1st year master courses are:

name C. van der Bunt date 12 - 09 - 2022 signature [redacted]

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (★) APPROVED ( ) NOT APPROVED
Procedure: (★) APPROVED ( ) NOT APPROVED

comments

name Monique von Morgen date 20 - 09 - 2022 signature [redacted]

Appendix A: Project Brief

Personal Project Brief - IDE Master Graduation

TU Delft

Interactive & hands-free instructional experience while cooking — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 19 - 09 - 2022 — 10 - 02 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

The context of the project is to research how people cook as well as how their experience can be supported/improved with the use of technology and Artificial Intelligence. The experience should resemble the experience of having a trusted friend guide you through cooking a recipe that they are an expert in. It should be based on where you are in the process, while allowing you to interact, manage, and ask questions along the way. The interaction could involve voice commands, hand gestures, expression recognition, eye movements, visuals, and/or sounds to enhance the experience. The main stakeholders are the company Verdify and the Swapmeals users. Verdify eventually would like to add the interface to their recipe-platform, Swapmeals with the intention to provide a better, modern interaction for their users.

Currently, there are 2 most commonly used methods for following instructions while cooking, namely, following written step-by-step instructions online/in a book or watching a tutorial video. This means the user must read and scroll/turn pages or press play/pause on a video all while cooking. Swapmeals currently provides instructions to their users online. Both interactions interrupt the user from cooking, take the user more time, and leave more room for mistakes than recipes that they know by heart. These points provide opportunities to create interactions that reduce these interruptions, help the process along, and provide confidence in what they are doing.

Limitations that I expect to encounter are existing technologies and their shortcomings (Such as smart speakers misunderstanding you and expression recognition misinterpreting a look). In addition to this, I see many directions that this project could focus on (the technology, the communication interactions, the product persona, etc.) and may have to scale back and focus in on specific areas.

space available for images / figures on next page

Personal Project Brief - IDE Master Graduation

TU Delft

introduction (continued): space for images

image / figure 1:

image / figure 2:

Appendix A: Project Brief

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

There are 3 core problems that create opportunities for improving the users experience:

1. Having to switch between multiple tasks
Cause: When more than one task needs to be carried out at the same time
Effects: High cognitive workload (must keep overview of all tasks and when they need to be carried out), unsure of when and where to shift their attention, feeling stressed, forgetting tasks (could lead to burning food, for example)

2. Being restricted in using the device that is providing the instructions
Cause: Busy or dirty hands
Effects: Interrupts your current task (must touch device or to wash hands then touch device) - this can be repeated several times throughout experience

3. Not every step or instruction is useful or necessary for the user, or there is not enough information or elaboration
Cause: Instructions are not personalized to users proficiency or experience with that recipe
Effects: Increases the time to cook the recipe, the user may not fully read the instructions and skip important steps, decreases the enjoyability of cooking that recipe

These core problems can be addressed by researching user tasks, subtasks, timing, temporal tasks, etc. in order to determine what the assisting technology needs to know and do in order to improve their experience.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

I am going to research:

1. User cooking needs and how they imagine their optimal cooking experience to be
2. What the assisting technology needs to know to achieve this (Recognition/sensing, knowledge, etc.)
3. What it should do/present (Smart voice interaction, visuals, sounds, etc.)
4. When it should do this (Timing, measuring physical change)
5. How it should come across to the user (Tone-of-voice, personality)

I plan to deliver a complete description of how the product should work (description of necessary technology, wireframes, user flows) accompanied with a digital prototype that expresses the essence of the interaction experience (Created with a combination of available prototyping tools such as Teachable Machines, Voiceflow, Antetype, etc. I do not plan on creating the product myself).

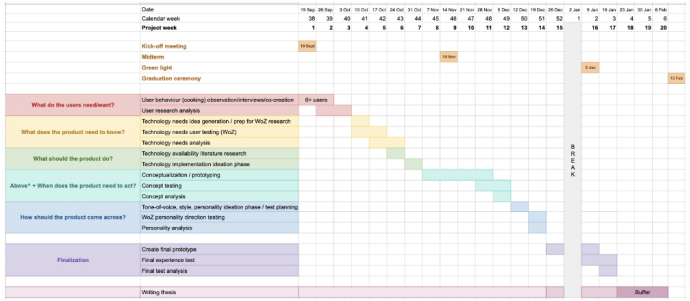
Personal Project Brief - IDE Master Graduation

TU Delft

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 19 - 9 - 2022 10 - 2 - 2023 end date



Appendix A: Project Brief

TU Delft

Personal Project Brief - IDE Master Graduation

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I set up this project based on my strong interest in how today's technology can improve our daily interactions in fundamental activities. Artificial intelligence and smart products are being implemented in all areas of our lives. I myself have a smart speaker that is connected to smart lights, a smart TV, and a smart camera. The addition of AI to these normal everyday products has made the interactions easier and more tailored to my needs. Incorporating smart technology in the cooking experience intrigues me for several reasons. Cooking is a considerable part of our everyday lives and many people do not enjoy it. Finding a way to make this essential daily task more enjoyable and easier for people to carry out would be so rewarding.

By completing this project, I would like to learn more about:
- The current AI technologies (digital assistants, expression recognition, eye tracking, etc.), their limitations, and the opportunities. (Building on the knowledge I obtained from the course Artificial Intelligence and Society)
- High-fidelity prototyping (I would like to create a prototype that exhibits the intended interactions as closely to how the real product would be experienced as possible.)
- Improve User Journey mapping skills

I would like to prove my existing skills in:
- User research, analysis, & implementation (with a strong focus on context)

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name KV Fenwick 5898 Student number

Title of Project Interactive & hands-free instructional experience while cooking

Appendix B: HREC Checklist

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

IMPORTANT NOTES ON PREPARING THIS CHECKLIST

1. An HREC application should be submitted for every research study that involves human participants (as Research Subjects) carried out by TU Delft researchers
2. Your HREC application should be submitted and approved **before** potential participants are approached to take part in your study
3. All submissions from Master's Students for their research thesis need approval from the relevant Responsible Researcher
4. The Responsible Researcher must indicate their approval of the completeness and quality of the submission by signing and dating this form OR by providing approval to the corresponding researcher via email (included as a PDF with the full HREC submission)
5. There are various aspects of human research compliance which fall outside of the remit of the HREC, but which must be in place to obtain HREC approval. These often require input from internal or external experts such as Faculty Data Stewards, Faculty HSE advisors, the TU Delft Privacy Team or external Medical research partners.
6. You can find detailed guidance on completing your HREC application here
7. Please note that incomplete submissions (whether in terms of documentation or the information provided therein) will be returned for completion **prior to any assessment**
8. If you have any feedback on any aspect of the HREC approval tools and/or process you can leave your comments here

I.

I. Applicant Information

PROJECT TITLE:	Interactive & hands-free instruction-based cooking experience
Research period: *Over what period of time will this specific part of the research take place*	Approximately 3 October - 15 October
Faculty:	Industrial Design Engineering
Department:	Human-Centered Design
Type of the research project: *(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)*	Master's
Funder of research: *(EU, NWO, TUD, other – in which case please elaborate)*	[redacted]
Name of Corresponding Researcher: *(If different from the Responsible Researcher)*	Kayla Fenwick
E-mail Corresponding Researcher: *(If different from the Responsible Researcher)*	[redacted]
Position of Corresponding Researcher: *(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)*	Master student
Name of Responsible Researcher: ***Note**: all student work must have a named Responsible Researcher to approve, sign and submit this application*	Marco Rozendaal
E-mail of Responsible Researcher: *Please ensure that an institutional email address (**no Gmail, Yahoo, etc.**) is used for all project documentation/ communications including Informed Consent materials*	[redacted]
Position of Responsible Researcher : *(PhD, PostDoc, Associate/ Assistant/ Full Professor)*	Associate professor

II. Research Overview

***NOTE**: You can find more guidance on completing this checklist here*

a) Please summarise your research very briefly (100-200 words)
What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbrevations)
For the purpose of understanding people's experiences while cooking, I will be observing how people cook in their home setting. There will be approximately 8 separate participants. They will be people I know (colleagues, friends, family, and neighbours). They will be expected to answer interview questions then cook a meal while I observe and take notes. The research has no budget and is therefore not funded.

b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

Add your text here – (please avoid jargon and abbrevations)

III. Risk Assessment and Mitigation Plan

NOTE: You can find more guidance on completing this checklist here

Please complete the following table in full for all points to which your answer is "yes". Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of Personally Identifiable Information (PII) and/or Personally Identifiable Research Data (PIRD) which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alignment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that you're much more likely to need to resubmit your application if you neglect to identify potential risks, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
A: Partners and collaboration						
1. Will the research be carried out in collaboration with additional organisational partners such as: • One or more collaborating research and/or commercial organisations • Either a research, or a work experience internship provider[1] [1] *If yes, please include the graduation agreement in this application*		X				
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? *If yes please provide a copy of the signed DTA/DPA*		X				
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? *If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below*		X				
B: Location						

Appendix B: HREC Checklist

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		X				
5. Will the research take place in a country or countries outside the EU?		X				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		X				
C: Participants						
7. Will the study involve participants who **may** be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).		X				
8. Will the study involve participants who **may** be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		X				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? *It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).*		X				
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?		X				
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups		X				
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)		X				

Appendix B: HREC Checklist

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third party data-gathering service, such as a survey platform?		X				
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		X				
E: Subject Matter *Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.*						
15. Will your research involve any of the following: • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and *In Vitro Diagnostic Medical* Devices Research		X				
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? *If yes see here to determine whether medical ethical approval is required*		X				
17. Will blood or tissue samples be obtained from participants? *If yes see here to determine whether medical ethical approval is required*		X				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		X				
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) *Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.*		X				
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)		X				
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? *If yes please attach the advice/ approval from the Privacy Team to this application*		X				
22. Does your research investigate causes or areas of conflict? *If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.*		X				

Appendix B: HREC Checklist

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences *If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.*		X				
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		X				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		X				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?		X				
27. Will the experiment involve the use of devices that are not 'CE' certified? *Only, if 'yes': continue with the following questions:*		X				
• Was the device built in-house?						
• Was it inspected by a safety expert at TU Delft? *If yes, please provide a signed device report*						
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? *If yes, please provide records of the inspection*						
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	X		**Covid could be passed from me to the participant or vice versa.**	**I will ensure that none of my participants are in a high-risk group for Covid. I will also cancel the session if I or any participant starts to feel unwell or tests positive for Covid.**		
29. Will your research involve **either:** a) "big data", combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants **and/or** b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		X				
G: Data Processing and Privacy						

Appendix B: HREC Checklist

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)	X		**I will be keeping their names for administrative and follow-up purposes. This could result in their names accidentally being released and associated with their research session.**	**I plan to keep their names tangibly and not digitally so there is a low risk of it being released digitally. Tangibly I will keep it locked in my filing cabinet within my private apartment. This should minimize the risk of the names being released. After the project, I will shred and recycle the paper.**		
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and **what other Personal Research Data** (including personal or professional views) will you be collecting?	X		I will be collecting video, photos, gender, and age. If the video or photos are released, it might upset the participant as it shows them cooking in their private homes. Gender and age being released may allow them to be identified which is a breach of privacy.	I will make sure the participant is fully comfortable with being recorded and make sure they know that they do not have to agree to it. If I use images in my thesis, I will blur out their faces and identifying features to the point where it would be impossible to recognize them. I will also permanently delete all footage once the project is finished. Their gender and age will be stored digitally but never associated with their name, image, or any other identifying information.		
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		X				
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	X		They could be recognized by their information in the thesis.	I will not mention any identifying data in the thesis that could be linked to the person (such as a name attached to a quote). I will fully blur out faces or identifying aspects (such as their face or a unique aspect in a kitchen). I will not include quotes that could identify the participant.		
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?		X				

Appendix B: HREC Checklist

H: More on Informed Consent and Data Management

NOTE: You can find guidance and templates for preparing your Informed Consent materials) here

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments here

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)

Kayla Fenwick

Signature of Corresponding Researcher:

[redacted]

Date: 21 September, 2022

Name of [redacted]

Signatur[redacted]esponsible Researcher:

Date: 23 September 2022

V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

Please also attach any of the following, if relevant to your research:

Document or approval	Contact/s
Full Research Ethics Application	After the assessment of your initial application **HREC will let you know if and when you need to submit additional information**
Signed, valid Device Report	Your Faculty HSE advisor
Ethics approval from an external Medical Committee	TU Delft Policy Advisor, Medical (Devices) Research
Ethics approval from an external Research Ethics Committee	Please append, if possible, with your submission
Approved Data Transfer or Data Processing Agreement	Your Faculty Data Steward and/or TU Delft Privacy Team
Approved Graduation Agreement	Your Master's thesis supervisor
Data Processing Impact Assessment (DPIA)	TU Delft Privacy Team
Other specific requirement	Please reference/explain in your checklist and append with your submission

Appendix C: Informed Consent Forms

Research Consent Form

Interactive & hands-free instruction-based cooking experience

Participant Information

You are being invited to participate in a research study titled "Interactive & hands-free instruction-based cooking experience". This study is being done by Kayla Fenwick with Marco Rozendaal, & Christina Schneegass as mentors from the TU Delft and in collaboration with Verdify.

The purpose of this research study is to gather insights from people's cooking experience with the aim of understanding how the experience can be improved. It will take you approximately *15* minutes to complete the interview questions in addition to however long your chosen recipe takes to cook. The data will be used for analyzing in order to make design decisions throughout the Graduation Project. The thesis will ultimately be published to the Delft Repository website and Verdify's archives. We will be asking you to provide demographic information (such as age and gender) and information on your cooking habits. We will also be asking you to allow for audio recordings, video recordings, and/or photos to be taken for analyzing and future reference purposes (please specify your decision below). **No identifying information will be included in the thesis.**

Audio recordings:
☐ Consent
☐ Do not consent

Photos:
☐ Consent
☐ Do not consent

Video recording:
☐ Consent
☐ Do not consent

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by not storing this consent form digitally. Your name will never be connected to your demographic or any other information. Your demographic information will never be connected to audio recordings, video recordings, or photos. All information (with the exception of your name) will be stored on Google Drive.

Your participation in this study is entirely voluntary **and you can withdraw at any time**. You are free to omit any questions. Your data can be removed from the research within 2 weeks after the study.

Corresponding researcher:
Name: Kayla Fenwick
Email address: [redacted]

Responsible researcher:
Name: Marco Rozendaal
Email address: [redacted]

Explicit Consent points

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *D D / M M / Y Y Y Y*, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: [*see points below*]	☐	☐

- *Written notes*
- *Audio recordings and/or video recordings (if consented to)*
  - *These recordings will be studied and transcribed as text then ultimately permanently destroyed*
- *Photos (if consented to)*
  - *These may be used in the thesis with blurring of identifying aspects (such as the face or parts of the room)*		

4. I understand that I will not be compensated for my participation.	☐	☐
5. I understand that the study will end after the meal has been prepared and the closing interview is finished (approximately 15 minutes total for both opening and closing interviews in addition to the time it takes to cook the chosen recipe).	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study involves the following risks: data breach of interview answers & recordings and potential exposure to Covid-19. I understand that these will be mitigated by keeping names offline, separating pieces of identifying information from each other, not storing information on Google Drive, and self-testing for Covid-19. You may also ask for the session to stop at any moment during the session (and up to 2 weeks following the session) and all information will be destroyed.	☐	☐
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) (your name) and associated personally identifiable research data (PIRD) (audio, film, photos, gender, age) with the potential risk of my identity being revealed in the event of a data breach. These risks are mitigated by separating them digitally and non-digitally.	☐	☐
8. I understand that the following steps will be taken to minimize the threat of a data breach, and protect my identity in the event of such a breach: Blurring of identifying features, transcribing audio recordings, and destroying files after use.	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
9. I understand that personal information collected about me that can identify me, such as my name, age, gender, occupation, etc., will not be shared beyond the study team. Verdify will not have access to this information.	☐	☐
11. I understand that the (identifiable) personal data I provide will be destroyed after the project has been completed (10 February, 2023).	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
12. I understand that after the research study the de-identifiable information I provide will be used for the Master Thesis that will be published on the Delft Repository website and Verdify's archives. Quotes and blurred images will not be connected to any identifying information.	☐	☐
13. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
16. I give permission for the de-identified photos, video-stills, transcripts, and interview answers that I provide to be archived in the Delft repository and Verdify repository so it can be used for future research and learning.	☐	☐
17. I understand that access to the Delft repository is open.	☐	☐

Signatures

_____	_____	_____
Name of participant [printed]	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name [printed]	Signature	Date

Appendix C: Informed Consent Forms

Concept Test

Research Consent Form

Interactive & hands-free instruction-based cooking experience

Participant Information

You are being invited to participate in a research study titled "Interactive & hands-free instruction-based cooking experience". This study is being done by Kayla Fenwick with Marco Rozendaal & Christina Schneegass as mentors from the TU Delft and in collaboration with Verdify.

The purpose of this research study is to test two prototype concepts that are meant to improve the cooking experience. The goal is to gather rich insights by comparing two extreme concepts. The aim is to find out what works, what can be improved, and which aspects of each concept can be combined in order to recommend a final design. The whole process should take approximately 1 hour, including interviews and cooking with the prototypes. The data will be used for analyzing in order to make the final design decisions for the Graduation Project. The thesis will ultimately be published to the Delft Repository website and Verdify's archives. You will be asked to provide demographic information (such as age and gender) and information on your cooking habits. You will also be asked to allow for audio recordings, video recordings, and/or photos to be taken for analyzing and future reference purposes (please specify your decision below). **No identifying information will be included in the thesis.**

Audio recordings:
- ☐ Consent
- ☐ Do not consent

Photos:
- ☐ Consent
- ☐ Do not consent

Video recording:
- ☐ Consent
- ☐ Do not consent

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by not storing this consent form digitally. Your name will never be connected to your demographic or any other information. Your demographic information will never be connected to audio recordings, video recordings, or photos. All information (with the exception of your name) will be stored on Google Drive.

Your participation in this study is entirely voluntary **and you can withdraw at any time**. You are free to omit any questions. Your data can be removed from the research within 2 weeks after the study.

Corresponding researcher:
Name: Kayla Fenwick
Email address: [redacted]

Responsible researcher:
Name: Marco Rozendaal
Email address: [redacted]

Explicit Consent points

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *D D / M M / Y Y Y Y*, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: [*see points below*]	☐	☐

- *Written notes*
- *Audio recordings and/or video recordings (if consented to)*
  - *These recordings will be studied and transcribed as text then ultimately permanently destroyed*
- *Photos (if consented to)*
  - *These may be used in the thesis with blurring of identifying aspects (such as the face or parts of the room)*		

4. I understand that I will not be compensated for my participation.	☐	☐
5. I understand that the study will end after the meal has been prepared and the closing interview is finished (approximately 15 minutes total for both opening and closing interviews in addition to the time it takes to cook the chosen recipe).	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
6. I understand that taking part in the study involves the following risks: data breach of interview answers & recordings and potential exposure to Covid-19. I understand that these will be mitigated by keeping names offline, separating pieces of identifying information from each other, not storing information on Google Drive, and self-testing for Covid-19. You may also ask for the session to stop at any moment during the session (and up to 2 weeks following the session) and all information will be destroyed.	☐	☐
7. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) (your name) and associated personally identifiable research data (PIRD) (audio, film, photos, gender, age) with the potential risk of my identity being revealed in the event of a data breach. These risks are mitigated by separating them digitally and non-digitally.	☐	☐
8. I understand that the following steps will be taken to minimize the threat of a data breach, and protect my identity in the event of such a breach: Blurring of identifying features, transcribing audio recordings, and destroying files after use.	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
9. I understand that personal information collected about me that can identify me, such as my name, age, gender, occupation, etc., will not be shared beyond the study team. Verdify will not have access to this information.	☐	☐
11. I understand that the (identifiable) personal data I provide will be destroyed after the project has been completed (10 February, 2023).	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
12. I understand that after the research study the de-identifiable information I provide will be used for the Master Thesis that will be published on the Delft Repository website and Verdify's archives. Quotes and blurred images will not be connected to any identifying information.	☐	☐
13. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
16. I give permission for the de-identified photos, video-stills, transcripts, and interview answers that I provide to be archived in the Delft repository and Verdify repository so it can be used for future research and learning.	☐	☐
17. I understand that access to the Delft repository is open.	☐	☐

Signatures

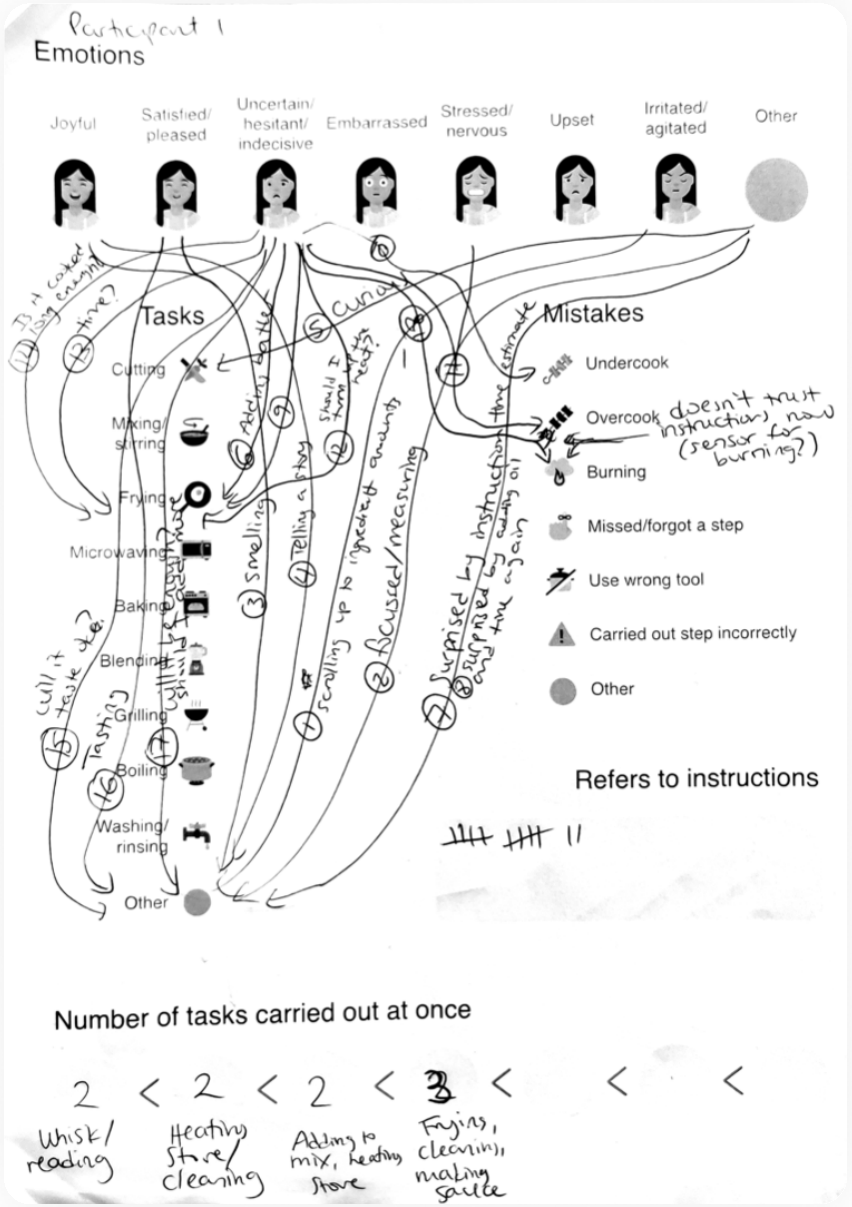
_____	_____	_____
Name of participant [printed]	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

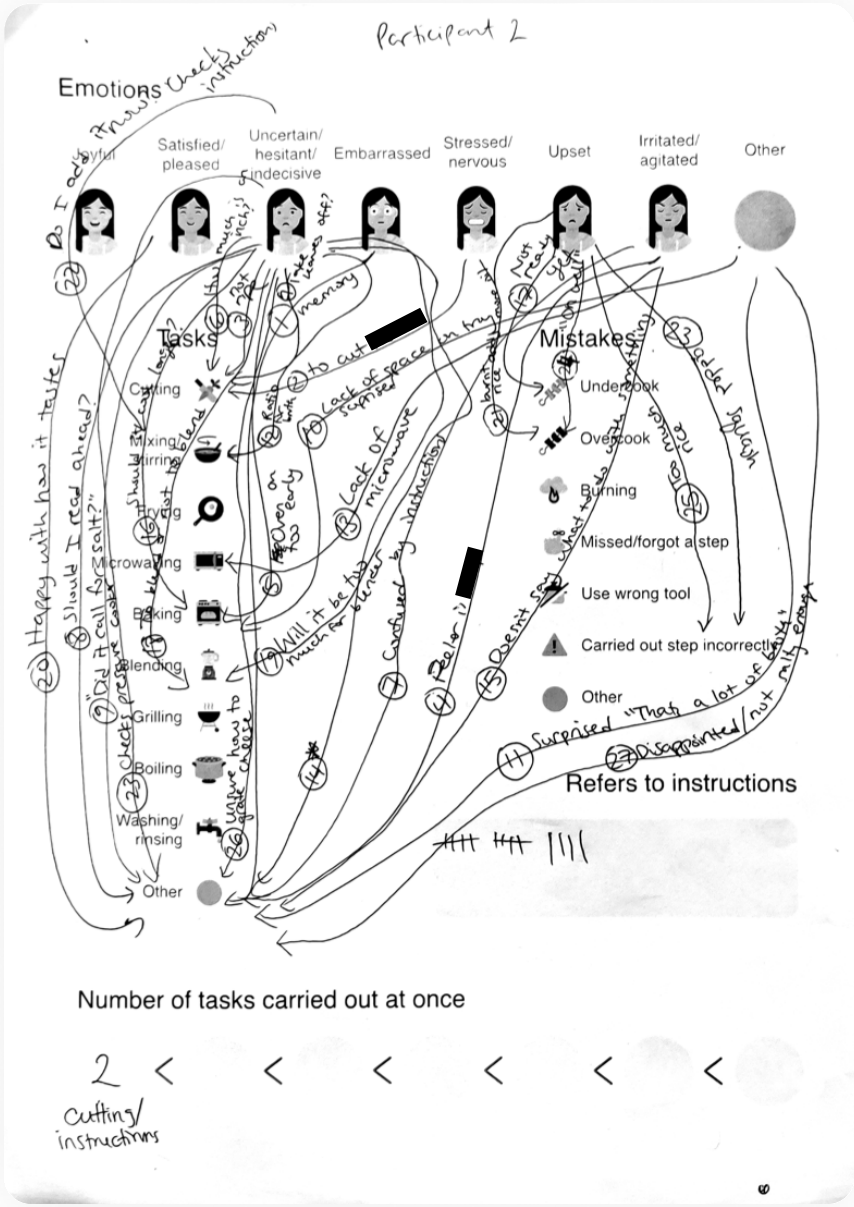
_____	_____	_____
Researcher name [printed]	Signature	Date

Appendix D: Filled in Notes Sheets

Participant 1

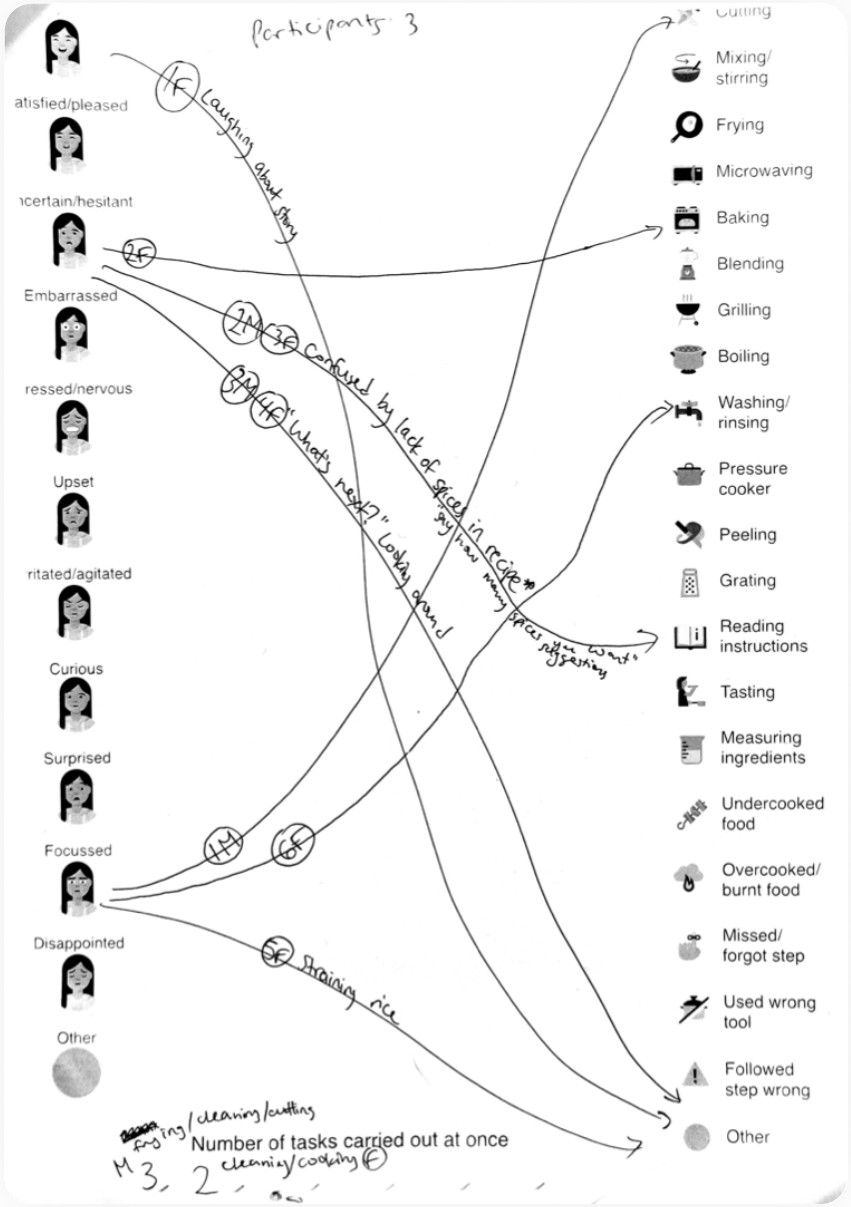


Participant 2

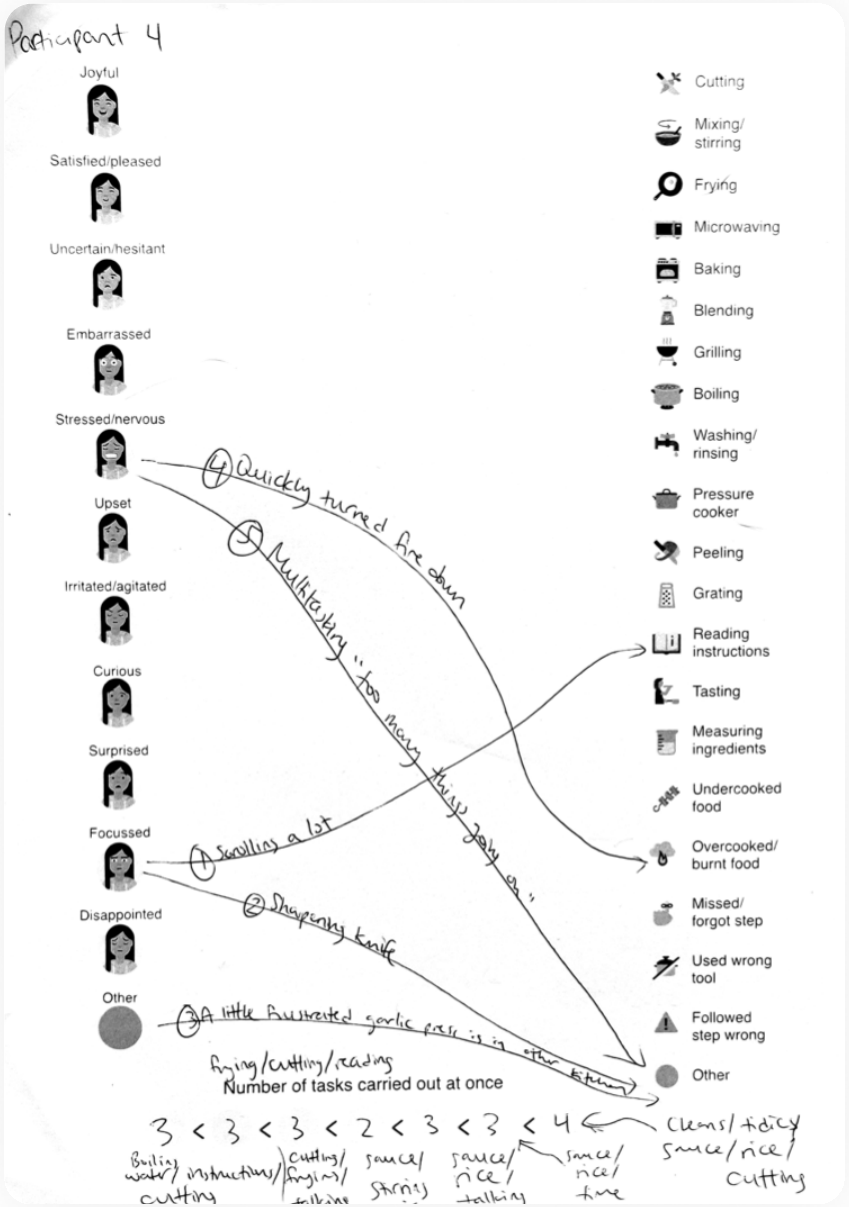


Appendix D: Filled in Notes Sheets

Participant 3

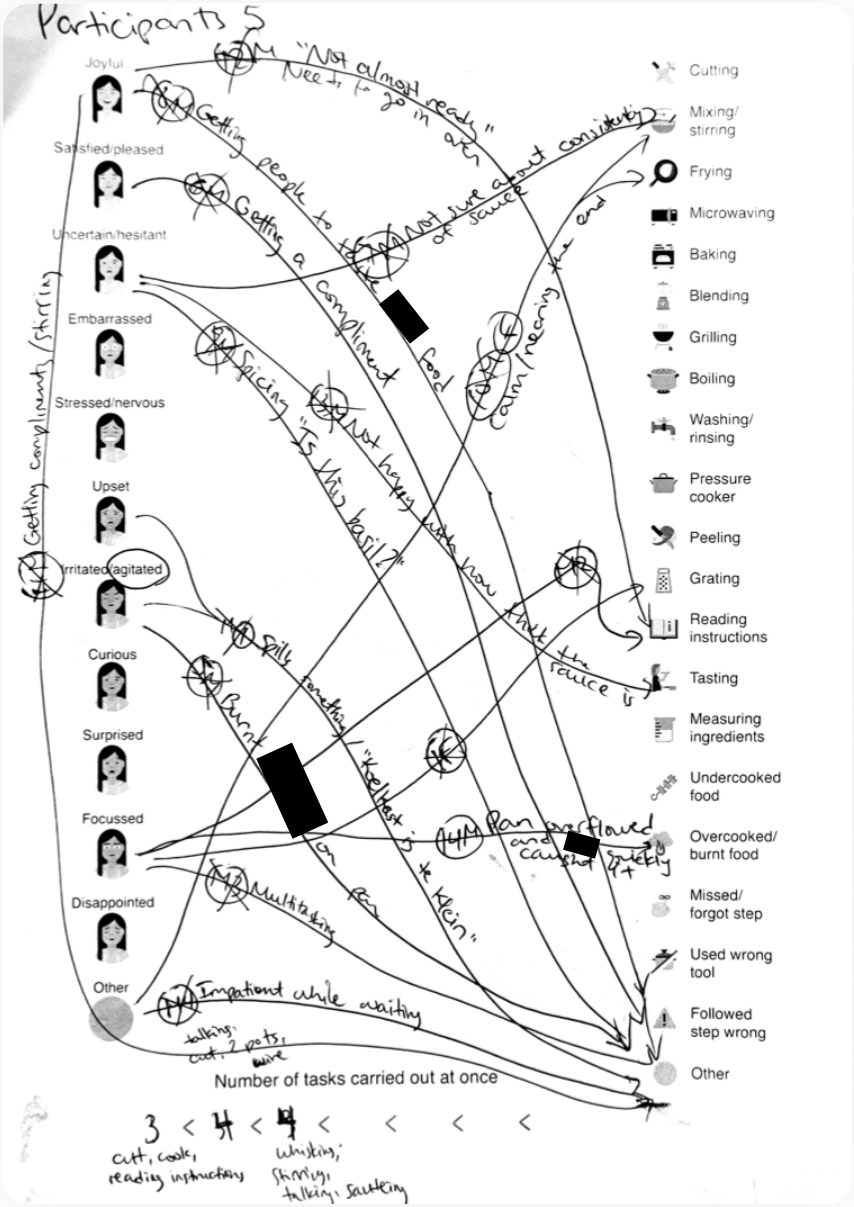


Participant 4

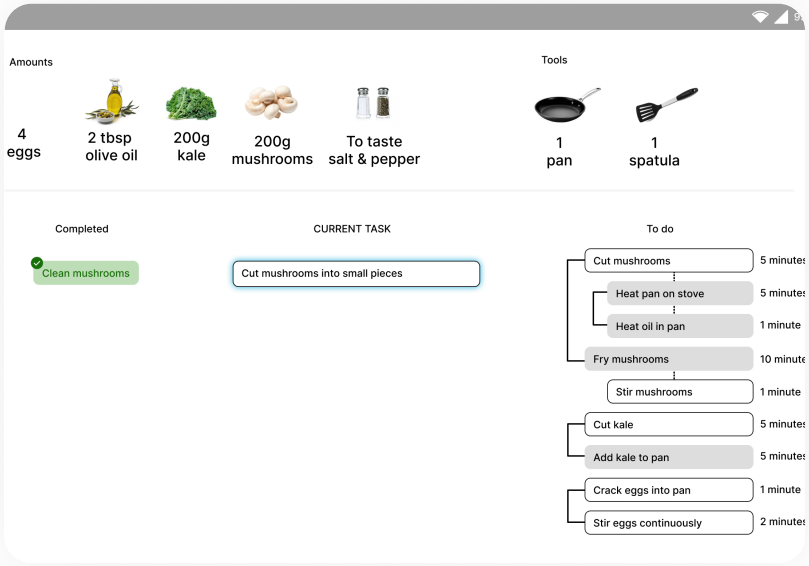


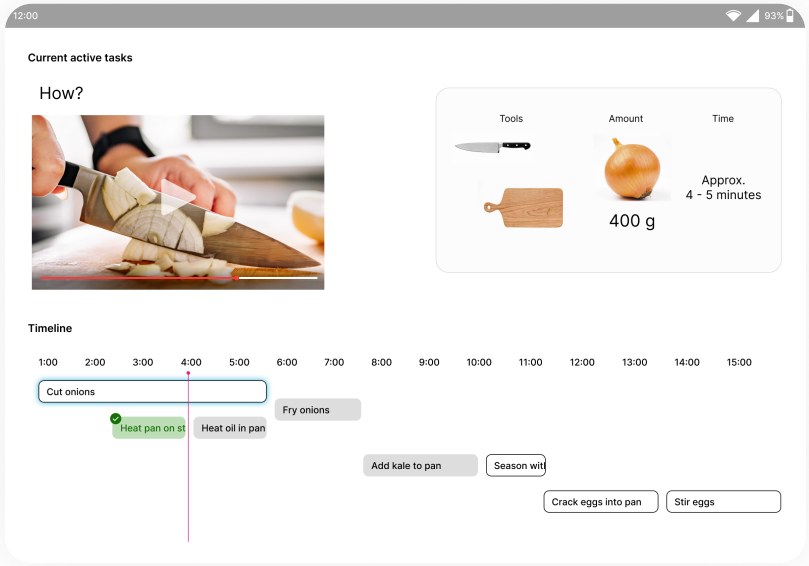
Appendix D: Filled in Notes Sheets

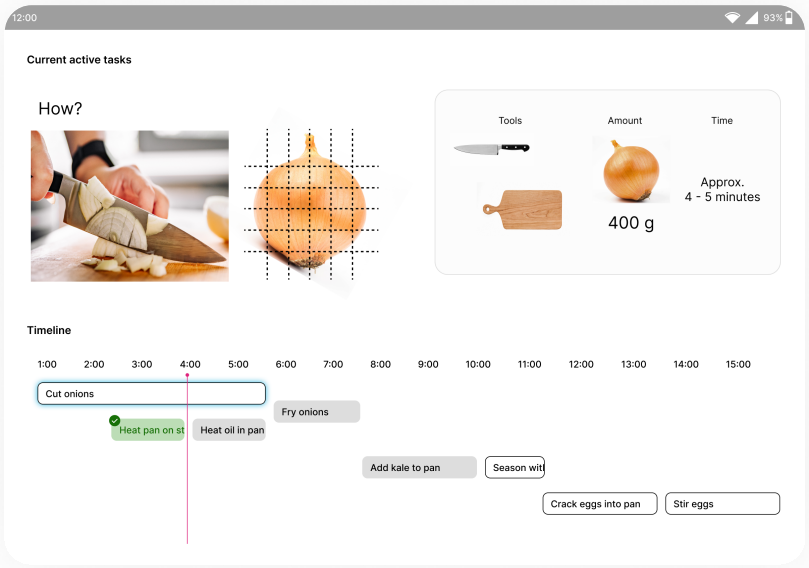
Participant 5

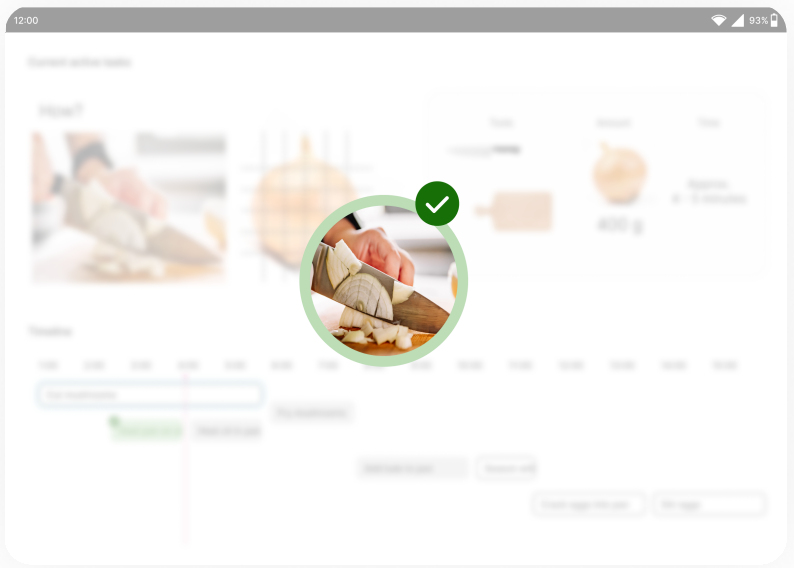


Appendix E: Additional Conceptualization Wireframes

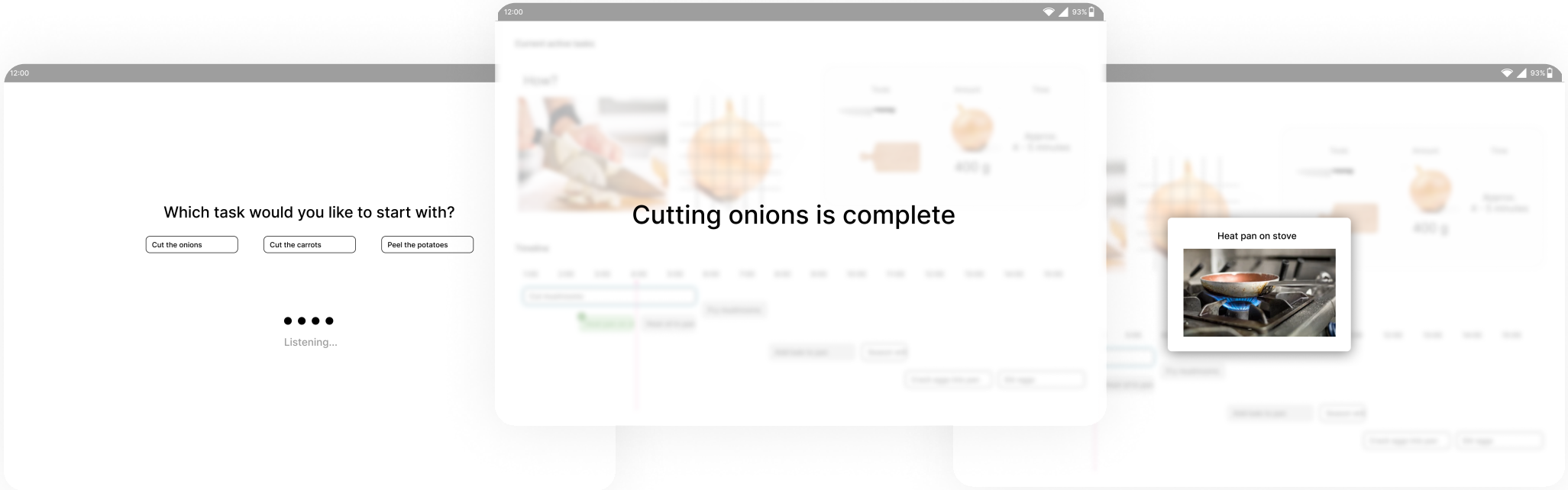


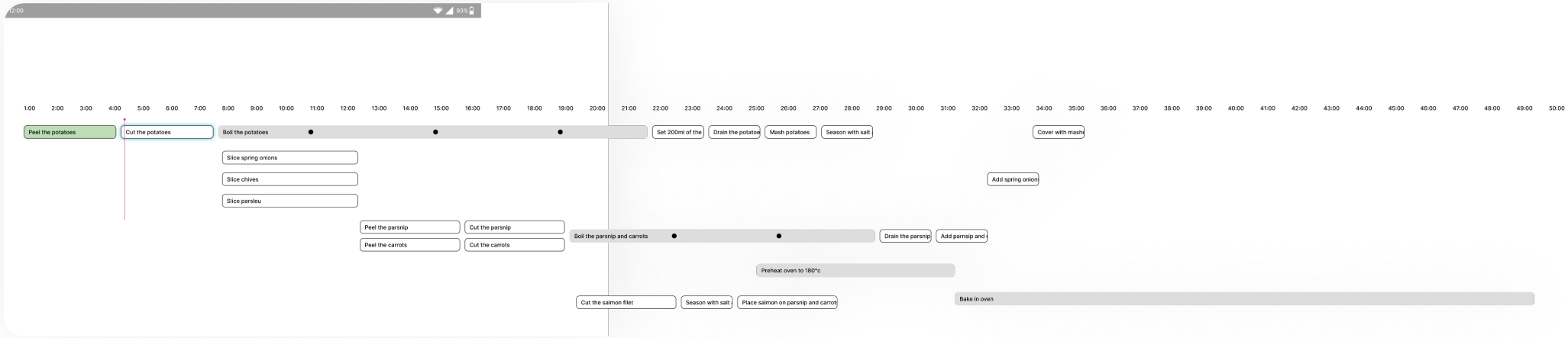






Appendix E: Additional Conceptualization Wireframes



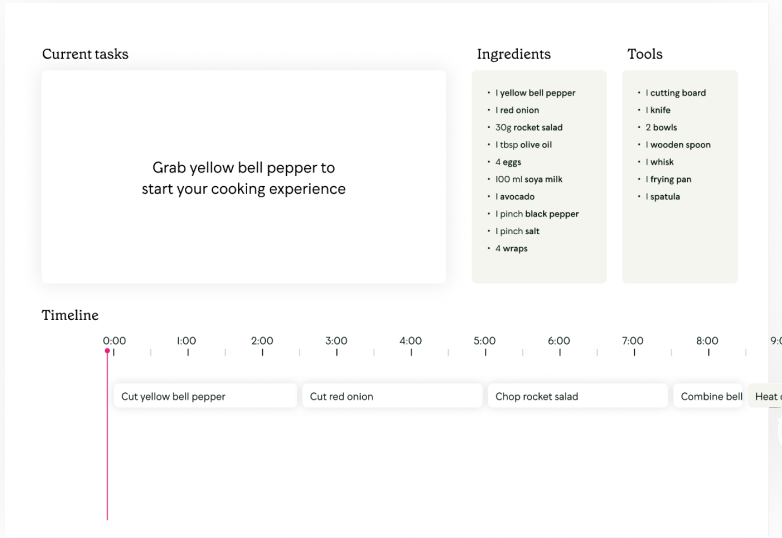


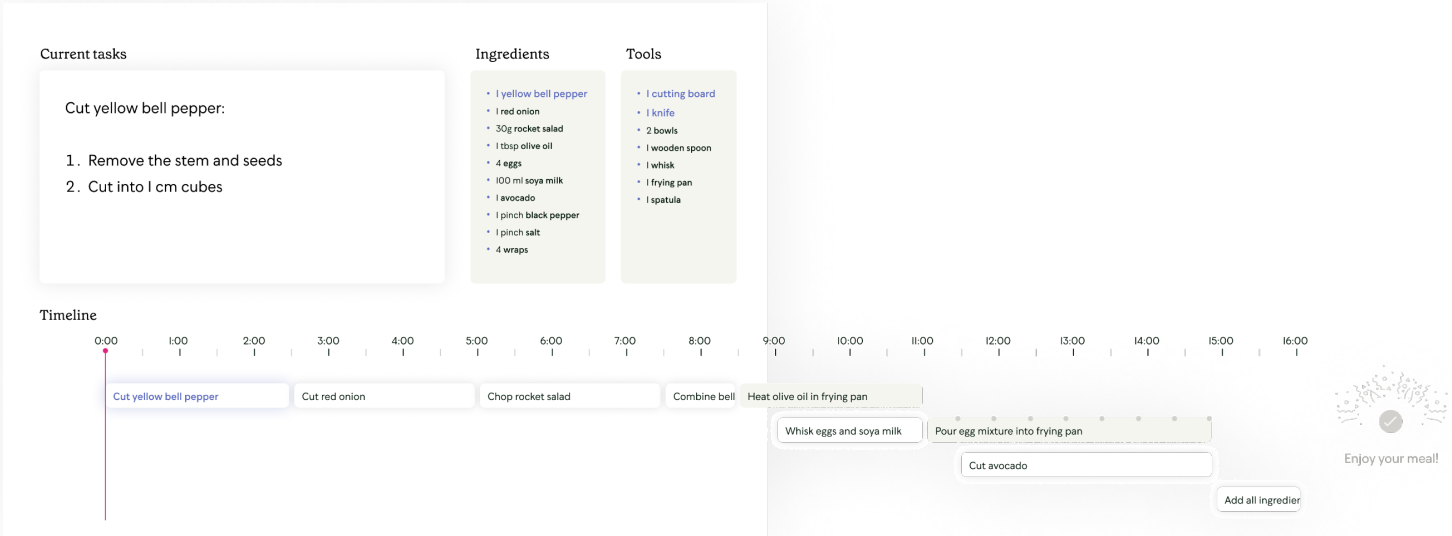
Appendix F: List of Verbal Instructions

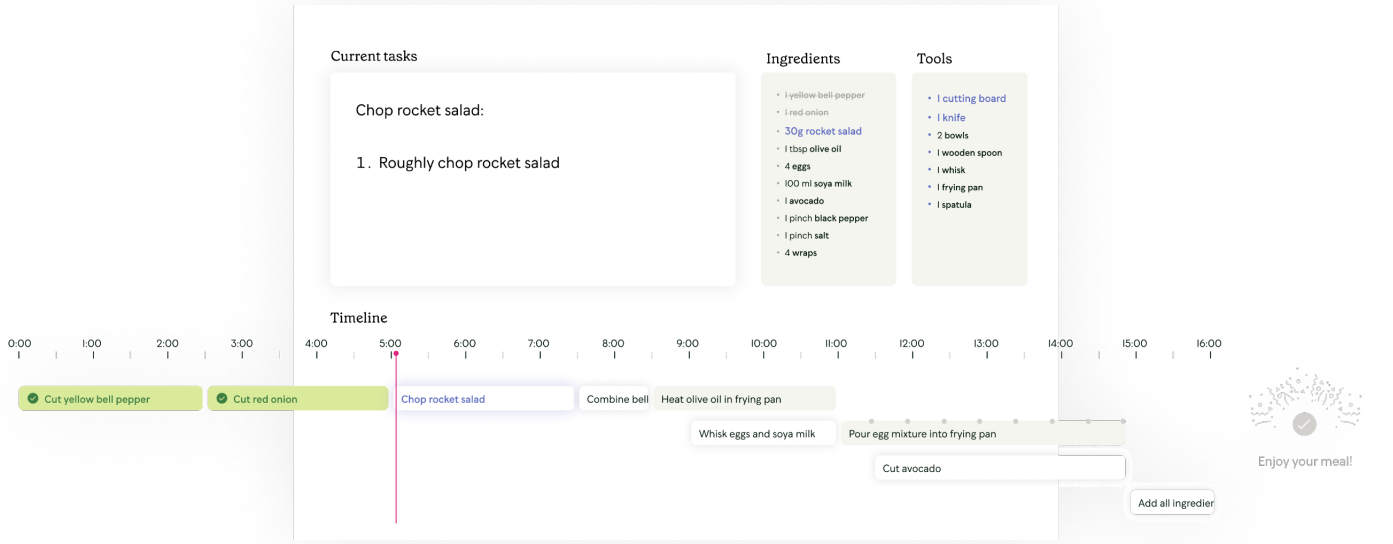
1. "Let me know when you're ready to begin."
2. "Remove the stem and seeds from the yellow bell pepper and cut it into about 1 cm sized cubes"
3. "Peel the skin from the onion and chop it into small pieces"
4. "Roughly chop up the rocket salad"
5. "Add the bell pepper, red onion, and rocket salad to a medium-sized bowl and mix together with the wooden spoon."
6. "Add the olive oil to the pan and mix it around with the spatula. Heat up the oil for about 2 ½ minutes."
7. "While the oil is heating up, crack the 4 eggs into a medium-sized bowl, add the soya milk to the eggs, and whisk until fully mixed.
8. "Pour the eggs into the pan and stir. I will remind you to stir every 15-20 seconds."
9. "While the eggs are cooking, cut the avocado in half"
10. "Stir"
11. "Remove the pit"
12. "Stir"
13. "Slice one avocado half into thin slices"
14. "Stir"
15. "Slice the other avocado half into thin slices"
16. "Stir"
17. "Scoop one half of the avocado out with a spoon"
18. "Stir"
19. "Scoop the other half of the avocado out"
20. "Stir"
21. "Remove eggs from heat
22. "Add the scrambled eggs to the wrap, place the salad mix next to the eggs, and the avocado on the other side of the eggs. Season to taste with salt and pepper. Enjoy!"

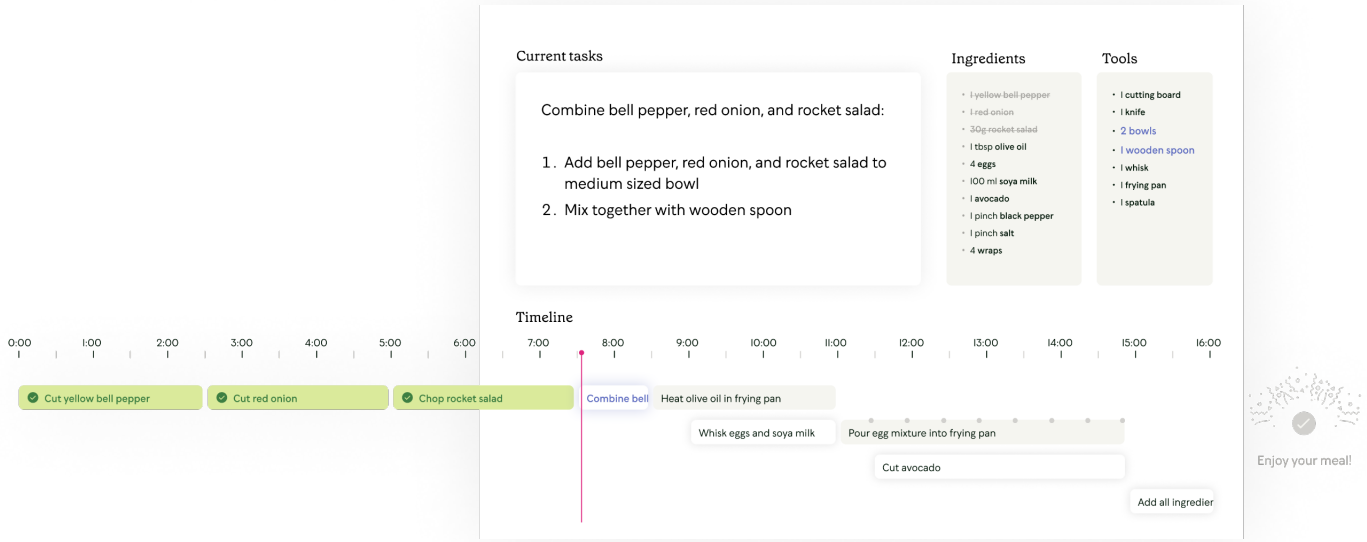
Appendix G: Additional Prototype Wireframes

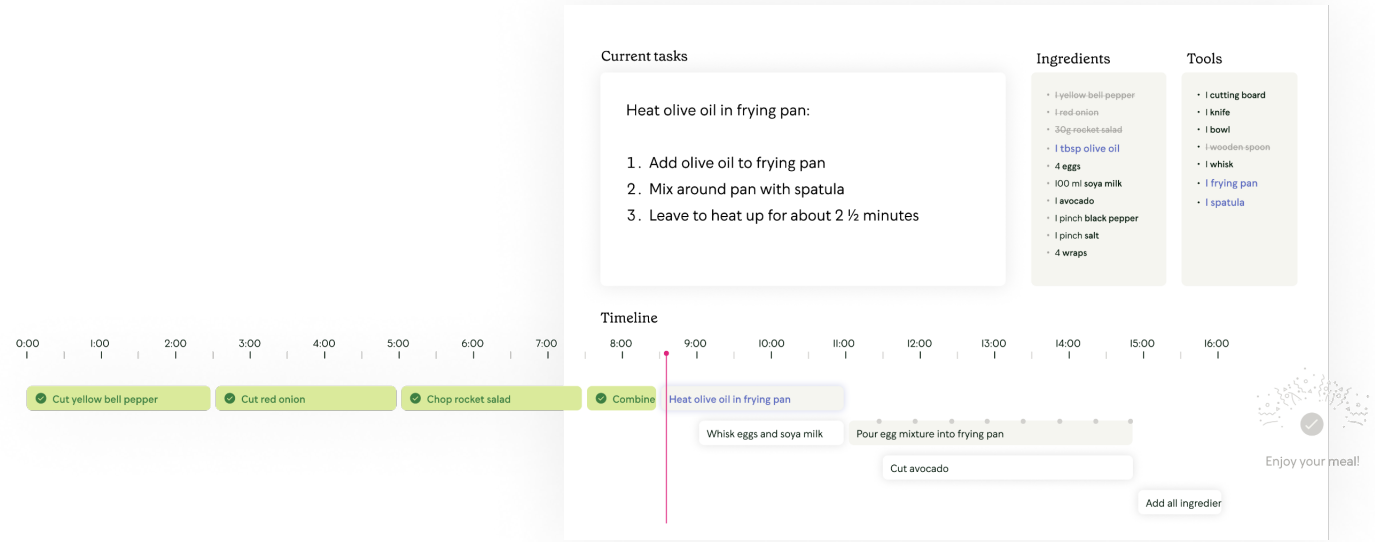
Textual & Action-based Prototype

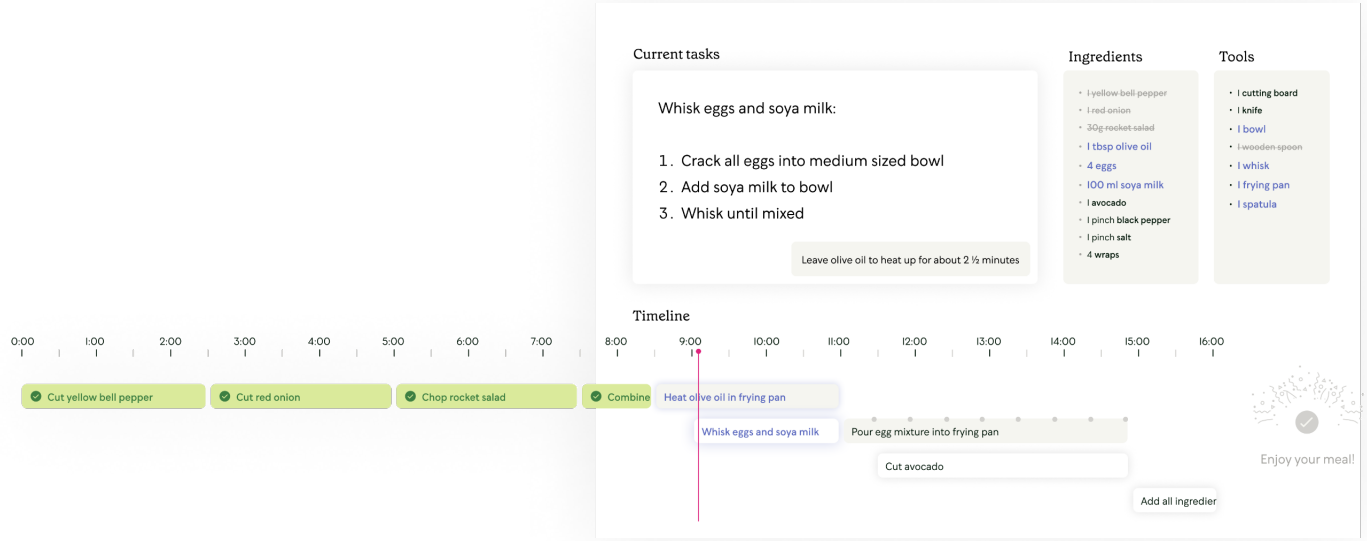


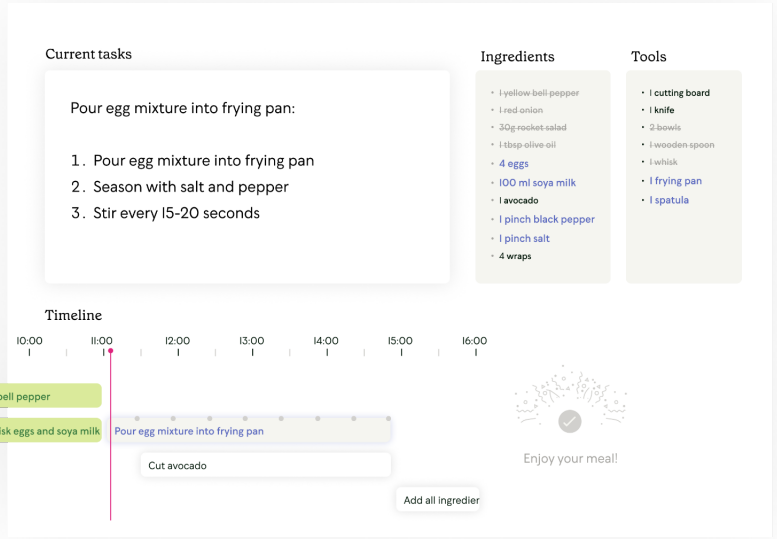


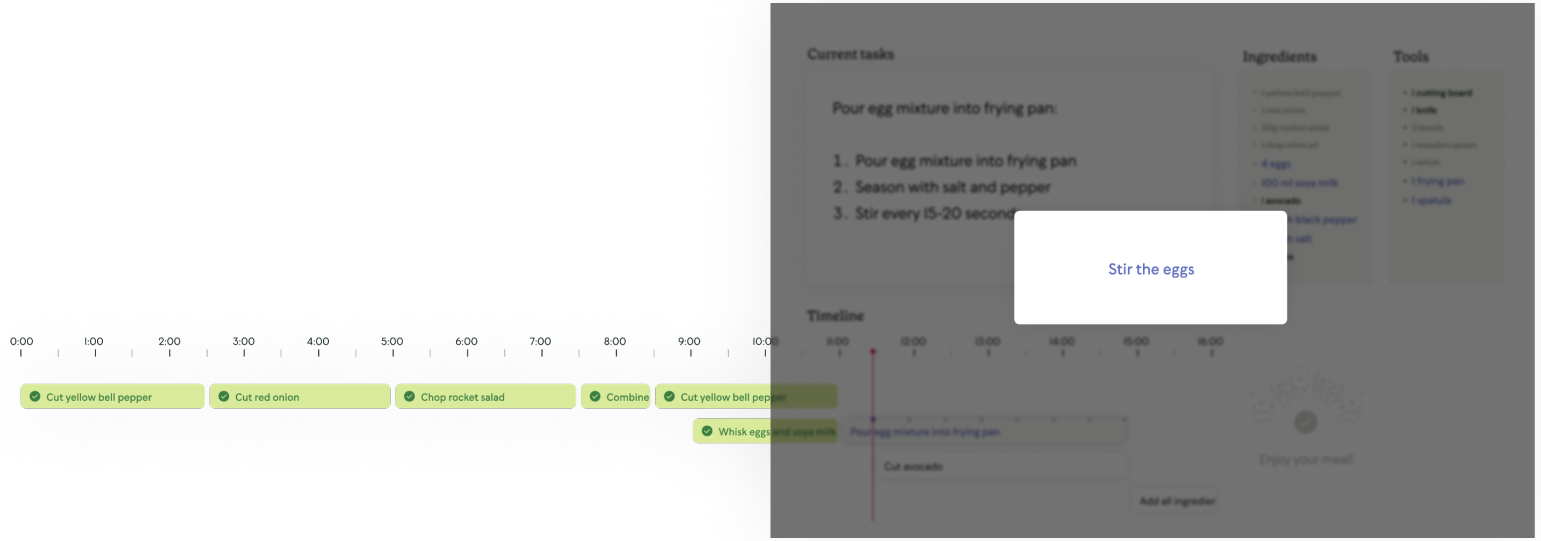

Current tasks
Chop rocket salad:
1. Roughly chop rocket salad
Ingredients
~~1 yellow bell pepper~~
~~1 red onion~~
30g rocket salad
1 tbsp olive oil
4 eggs
100 ml soya milk
1 avocado
1 pinch black pepper
1 pinch salt
4 wraps
Tools
1 cutting board
1 knife
2 bowls
1 wooden spoon
1 whisk
1 frying pan
1 spatula
Timeline
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine bell
Heat olive oil in frying pan
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Add all ingredier
Enjoy your meal!

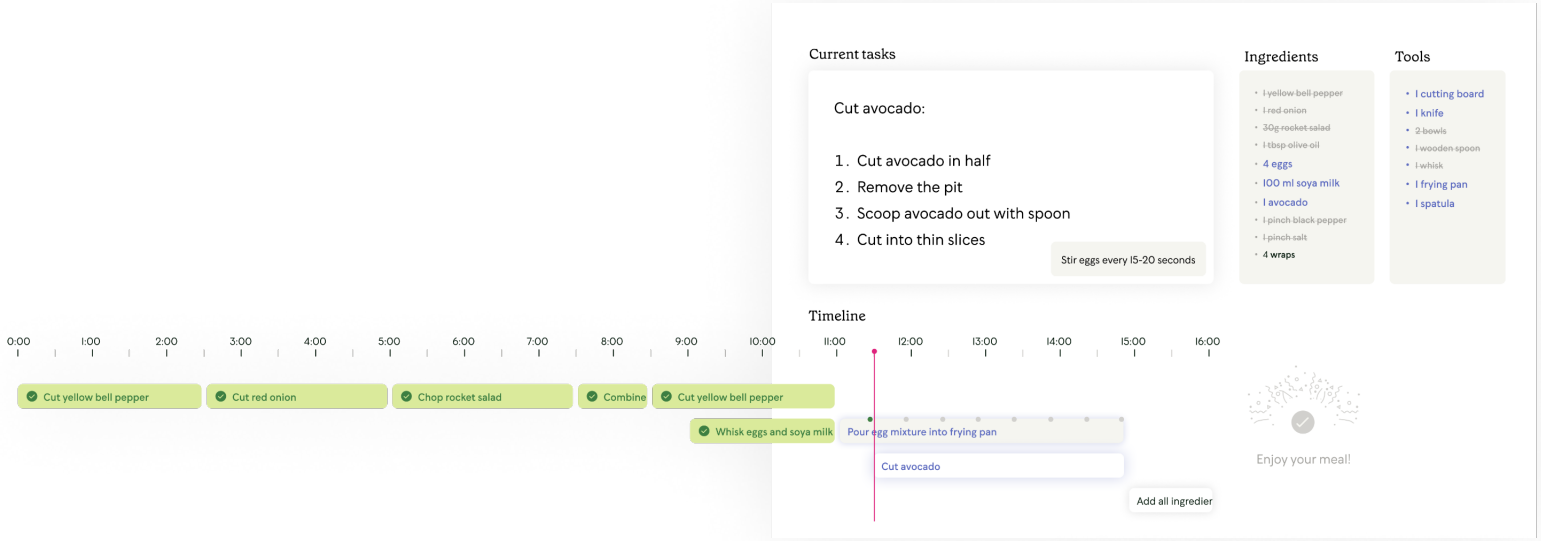

Current tasks
Combine bell pepper, red onion, and rocket salad:
1. Add bell pepper, red onion, and rocket salad to medium sized bowl
2. Mix together with wooden spoon
Ingredients
~~1 yellow bell pepper~~
~~1 red onion~~
~~30g rocket salad~~
1 tbsp olive oil
4 eggs
100 ml soya milk
1 avocado
1 pinch black pepper
1 pinch salt
4 wraps
Tools
1 cutting board
1 knife
2 bowls
1 wooden spoon
1 whisk
1 frying pan
1 spatula
Timeline
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine bell
Heat olive oil in frying pan
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Add all ingredier
Enjoy your meal!

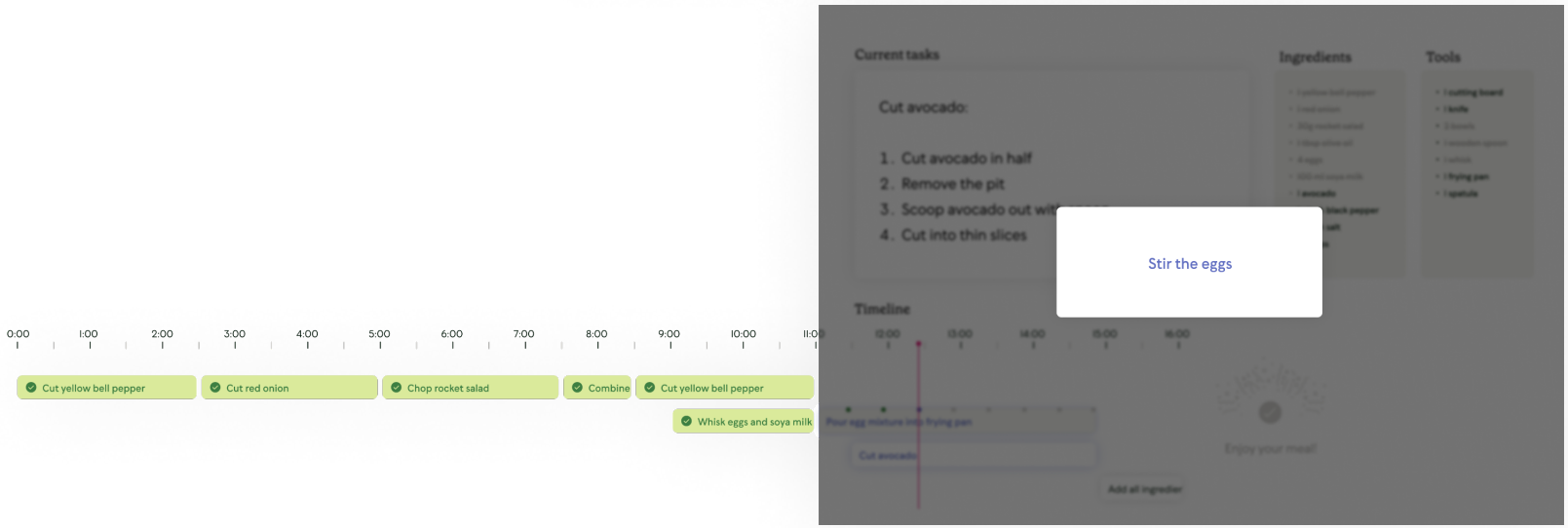

Current tasks
Heat olive oil in frying pan:
1. Add olive oil to frying pan
2. Mix around pan with spatula
3. Leave to heat up for about 2 ½ minutes
Ingredients
Tools
Timeline
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Heat olive oil in frying pan
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Enjoy your meal!

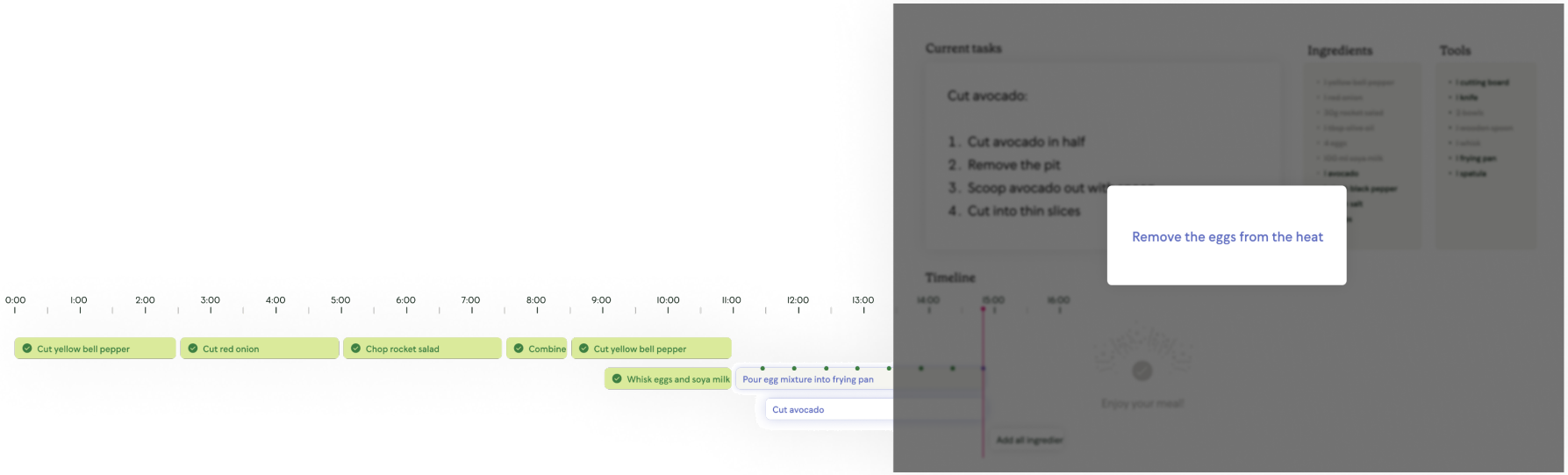

Current tasks
Whisk eggs and soya milk:
1. Crack all eggs into medium sized bowl
2. Add soya milk to bowl
3. Whisk until mixed
Leave olive oil to heat up for about 2 ½ minutes
Ingredients
Tools
Timeline
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Heat olive oil in frying pan
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Enjoy your meal!


Current tasks
Pour egg mixture into frying pan:
1. Pour egg mixture into frying pan
2. Season with salt and pepper
3. Stir every 15-20 seconds
Ingredients
Tools
Timeline
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Cut yellow bell pepper
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Enjoy your meal!


Current tasks
Pour egg mixture into frying pan:
1. Pour egg mixture into frying pan
2. Season with salt and pepper
Stir the eggs
Ingredients
Tools
Timeline
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Cut avocado


Current tasks
Cut avocado:
1. Cut avocado in half
2. Remove the pit
3. Scoop avocado out with spoon
4. Cut into thin slices
Stir eggs every 15-20 seconds
Ingredients
1 yellow bell pepper
1 red onion
30g rocket salad
1 tbsp olive oil
4 eggs
100 ml soya milk
1 avocado
1 pinch black pepper
1 pinch salt
4 wraps
Tools
1 cutting board
1 knife
2 bowls
1 wooden spoon
1 whisk
1 frying pan
1 spatula
Timeline
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Cut yellow bell pepper
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Add all ingredier
Enjoy your meal!

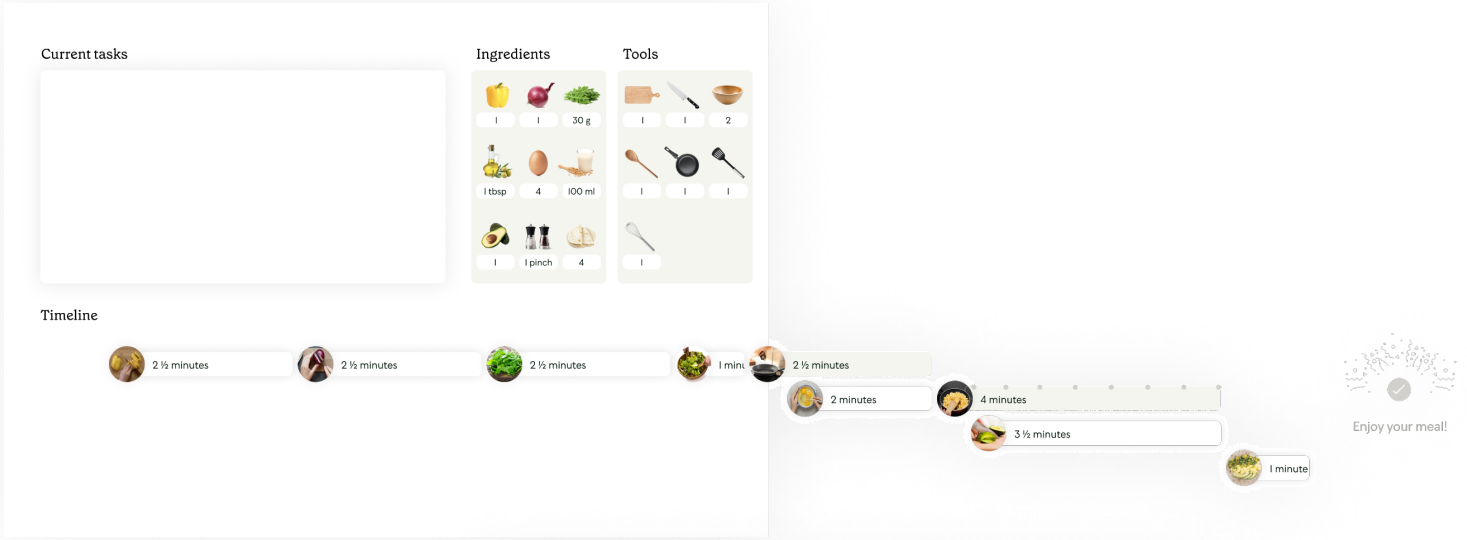

Current tasks
Cut avocado:
1. Cut avocado in half
2. Remove the pit
4. Cut into thin slices
Stir the eggs
Ingredients
Tools
Timeline
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Cut yellow bell pepper
Whisk eggs and soya milk

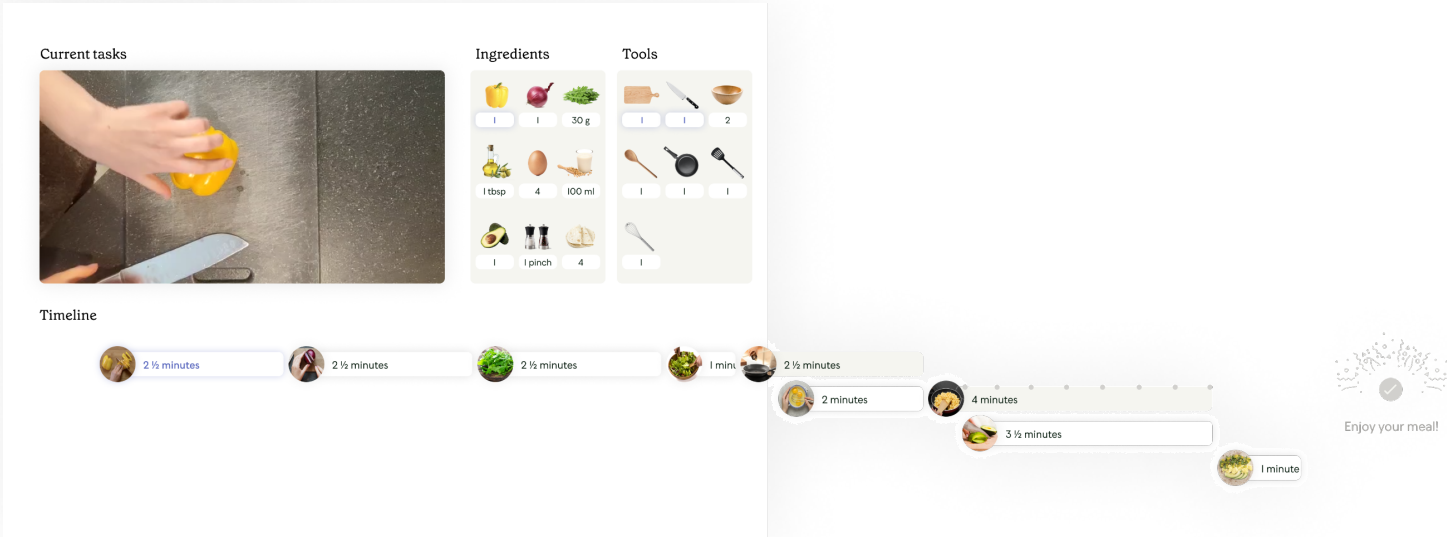

Current tasks
Cut avocado:
1. Cut avocado in half
2. Remove the pit
3. Scoop avocado out wit
4. Cut into thin slices
Ingredients
Tools
Remove the eggs from the heat
Timeline
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Cut yellow bell pepper
Whisk eggs and soya milk
Pour egg mixture into frying pan
Cut avocado
Enjoy your meal!
Add all ingredie

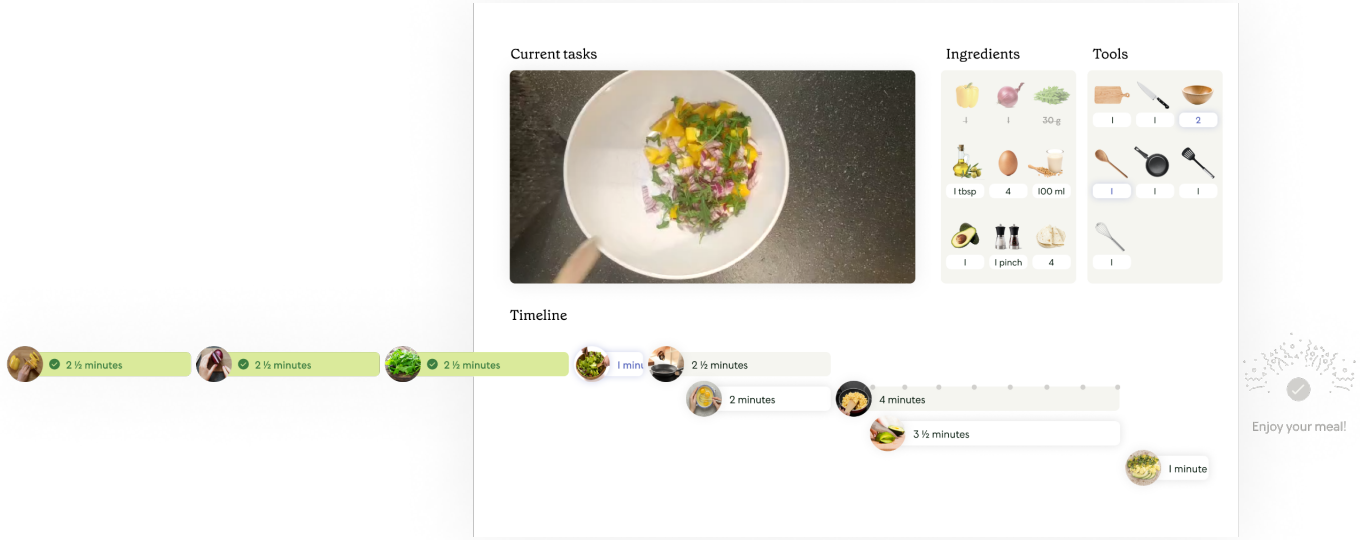

Current tasks
Ingredients
1 yellow bell pepper
1 red onion
30g rocket salad
1 tbsp olive oil
4 eggs
100 ml soya milk
1 avocado
1 pinch black pepper
1 pinch salt
4 wraps
Tools
1 cutting board
1 knife
2 bowls
1 wooden spoon
1 whisk
1 frying pan
1 spatula
Timeline
0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00
Cut yellow bell pepper
Cut red onion
Chop rocket salad
Combine
Cut yellow bell pepper
Whisk eggs and soya milk
Cut yellow bell pepper
Cut avocado
Add all ingre
Enjoy your meal!

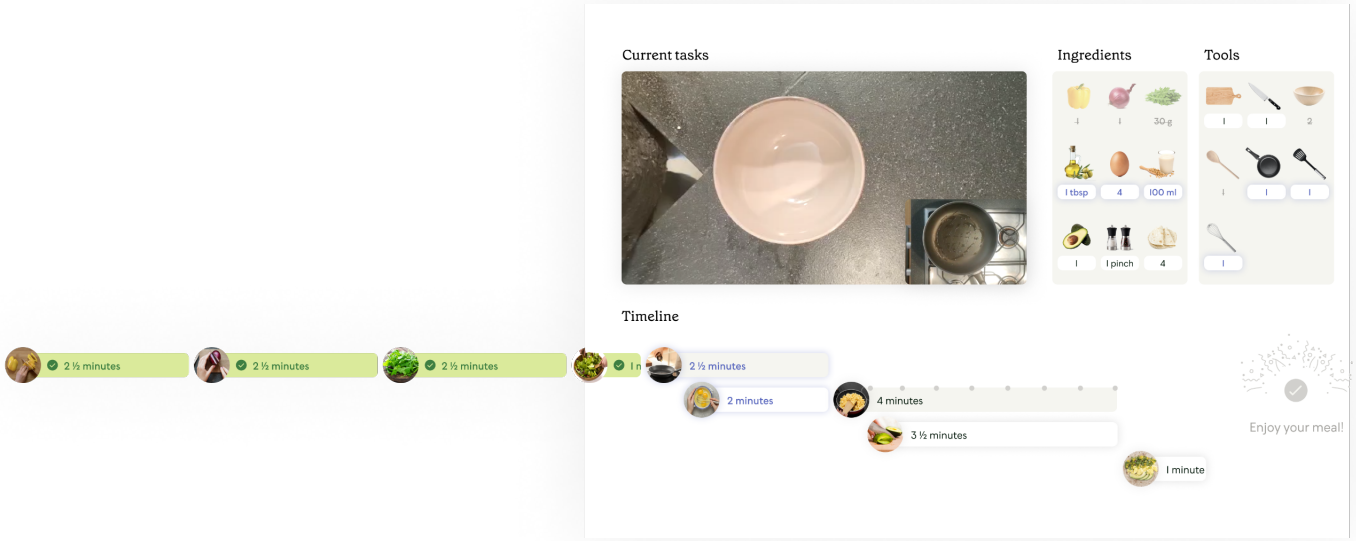
Appendix G: Additional Prototype Wireframes

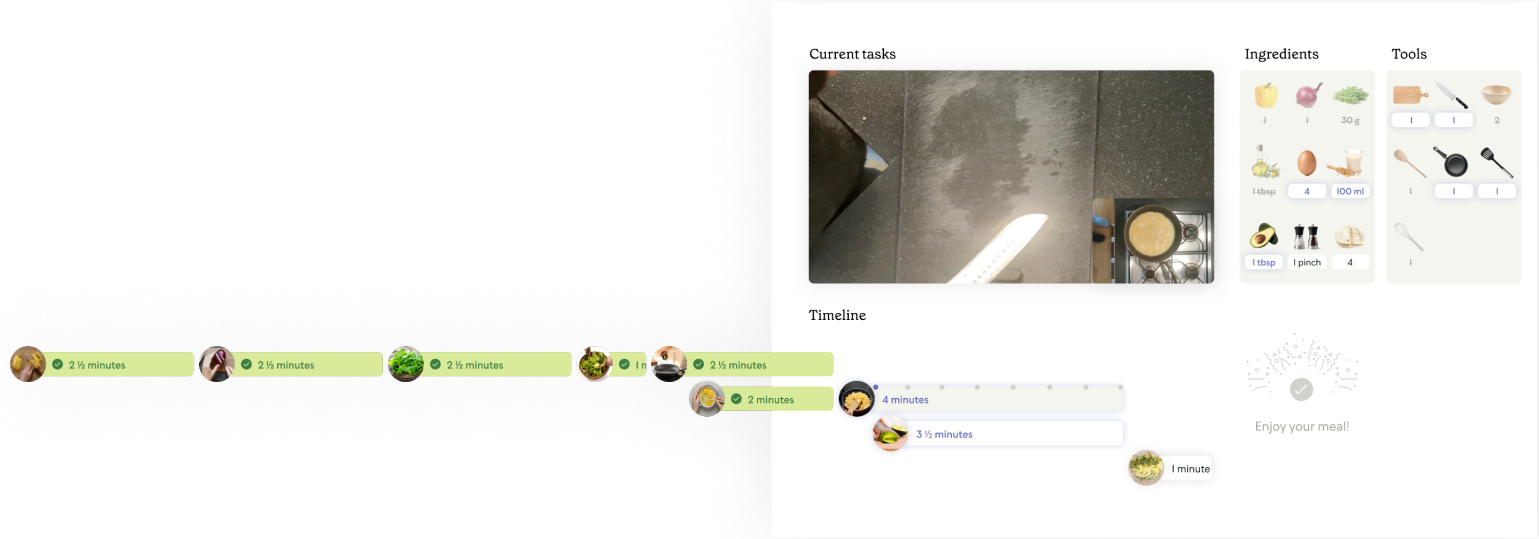
Visual & Verbal Prototype

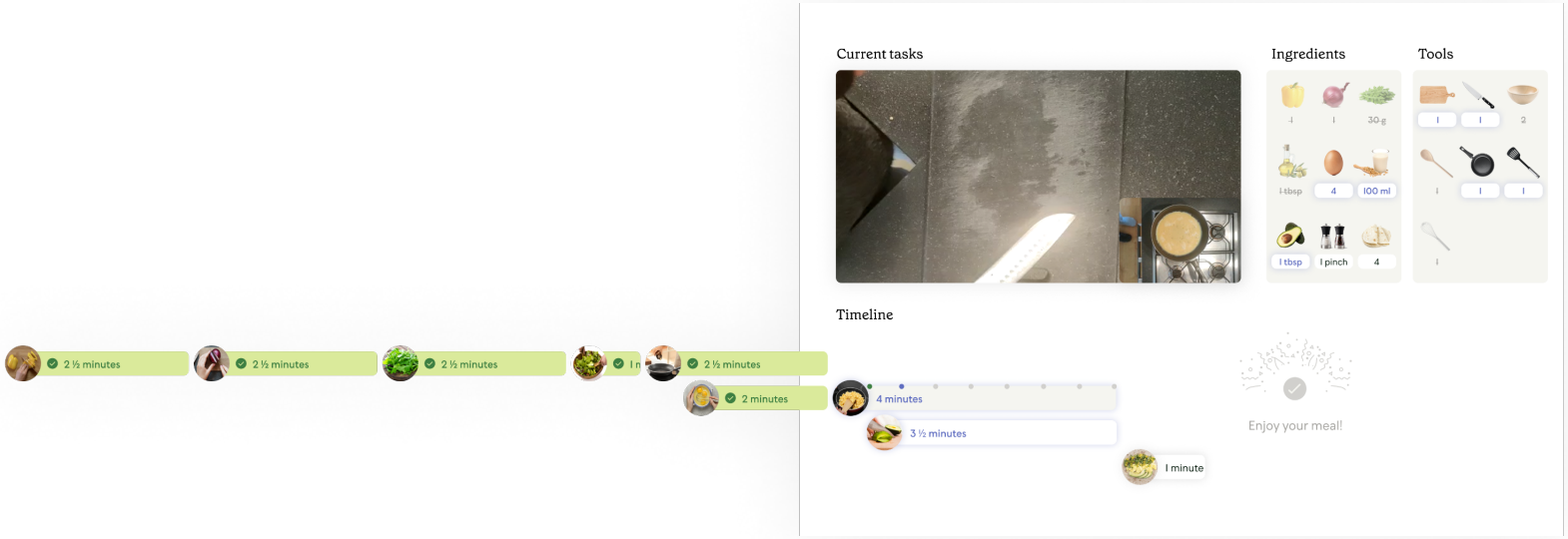


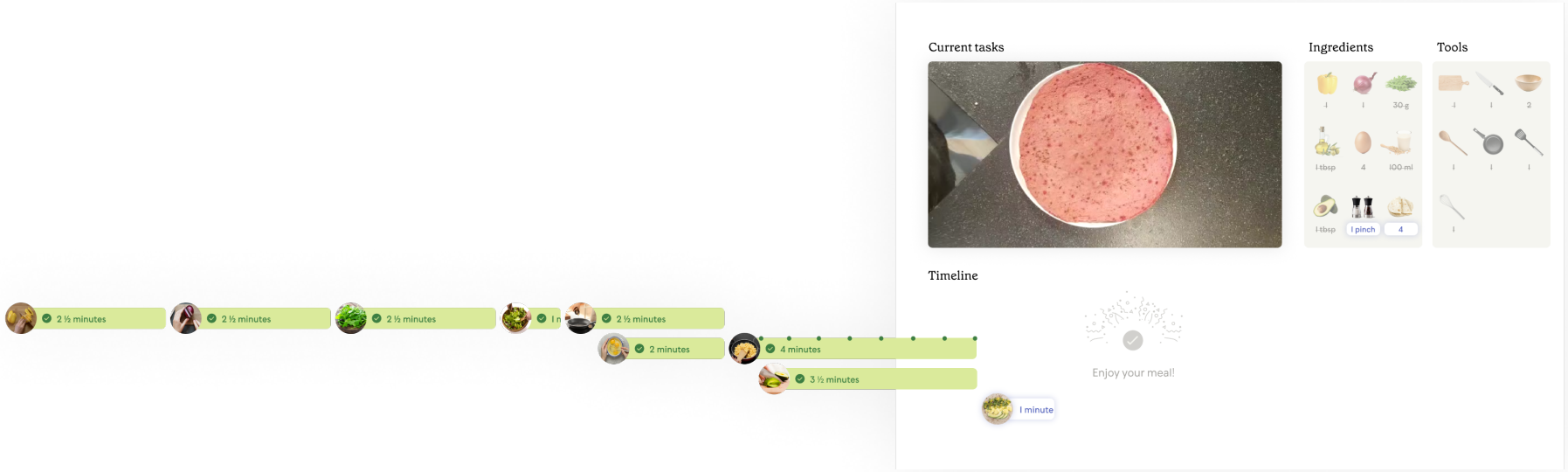


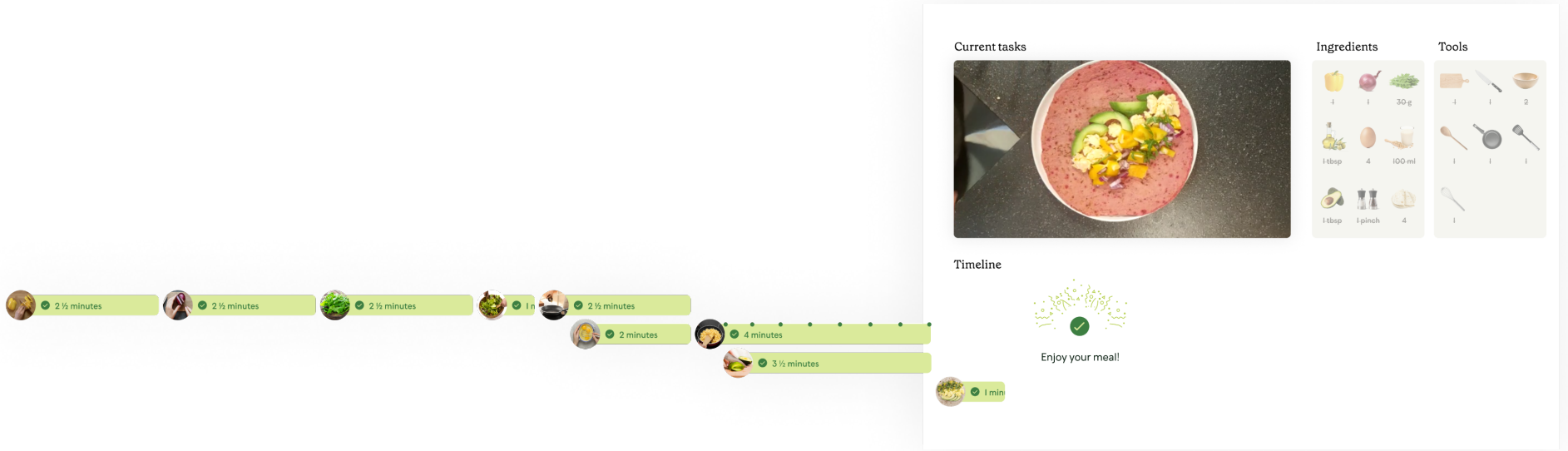

Current tasks
Ingredients
Tools
Timeline
2 ½ minutes
2 minutes
4 minutes
3 ½ minutes
1 minute
Enjoy your meal!


Current tasks
Ingredients
Tools
Timeline
2 ½ minutes
2 minutes
4 minutes
3 ½ minutes
1 minute
Enjoy your meal!


Current tasks
Ingredients
Tools
Timeline
2 ½ minutes
2 ½ minutes
2 ½ minutes
2 ½ minutes
2 minutes
4 minutes
3 ½ minutes
1 minute
Enjoy your meal!


Current tasks
Ingredients
Tools
Timeline
2 ½ minutes
2 ½ minutes
2 ½ minutes
2 minutes
4 minutes
3 ½ minutes
1 minute
Enjoy your meal!


Current tasks
Ingredients
Tools
Timeline
2 ½ minutes
2 minutes
4 minutes
3 ½ minutes
1 minute
Enjoy your meal!


Current tasks
Ingredients
Tools
Timeline
2 ½ minutes
2 minutes
4 minutes
3 ½ minutes
Enjoy your meal!