Supporting Recipe Modification through Novel Interface Design

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ABSTRACT

The usefulness of standard recipes is declining alongside cooking skill and food knowledge. Users are less able to infer abstract food properties such as taste and texture, which results in difficulty when a recipe must be modified. We create two novel interfaces to assist in the process of recipe modification with the goal of testing different methods of representing abstract food properties. The "Enhanced Recipe" shows textual information concerning the abstract food properties of the recipe. The System for Assisting Gustatory Envisionment (SAGE) uses interactive elements which give more direct representation to abstract food properties. We conduct a user study to test these interfaces against a standard recipe and each other in the domain of baking, using recipes for chocolate chip cookies. We find that it is possible to decrease task load using these interfaces, but that the challenge of imparting deeper food knowledge during interactions requires more research.

INTRODUCTION

Recipes provide integral support for the process of choosing and preparing food. They provide the basic information needed make a meal 'from scratch' including ingredients and their quantities, and the preparation instructions. In their standard form, recipes do not give readers direct access to abstract food properties (AFPs) such as taste, texture, nutritional value, and cost, which are important factors informing food decisions [source]. This information is provided only indirectly in the list of ingredients; it is left up to the reader to extract these factors from the list of ingredients by drawing on their food knowledge. In this way, the usefulness of recipes is limited by the food knowledge and preparation skills of the recipe reader.

There are signs that the standard recipe is no longer adequate for growing numbers of people. A 2010 meta-analysis by Health Canada notes a long-term decline in cooking and food preparation skills, and a related decrease in the consumption of meals made 'from scratch' in favour of processed, pre-prepared, and convenience foods [source]. In Canada, this trend can be seen across numerous cultural groups and socio-economic divides. The loss of food knowledge and preparation skills means that people are losing the ability to make informed food decisions, with regards to factors like health and quality. We propose that tools which remove some of the barriers to at-home food preparation can help to offset this trend of growing reliance on commercially prepared meals.

We propose that the static format of a typical recipe is not well suited to support AFP driven changes. Without external support, people are limited to their individual food knowledge and working memory. We see three challenges to making AFP motivated changes to a standard recipe: (1) the AFPs of the resulting dish must be derived from the recipe's ingredients and cooking techniques and encoded into working memory; (2) the relationship between ingredients and cooking methods to AFPs must be encoded in working memory, (3) Interactive effects between AFP modifications must be accounted for (e.g. when baking, sugar increases sweetness but can also change the resulting texture). This could be challenging even for those with high food knowledge, let alone the inexperienced.

We designed a study to answer two research questions: (1) Can the process of modifying recipes be improved to reduce user task burden through displaying AFPs and AFP information and (2) Is the presentation style of AFP information significant? To answer these questions, we created three prototypes with varying levels and methods of AFP information display. The first is a standard "Plain Recipe", with no AFP information. The second, the "Enhanced Recipe", provides a standard recipe alongside textual AFP "facts". For the third, we propose the System for Assisting Gustatory Envisionment (SAGE), an interactive recipe system that attempts to better support recipe modification by giving direct representation to the AFPs, and allowing users to directly manipulate them.

RELATED WORKS

Preparing and enjoying food is a universal human experience to which researchers and developers of technology have made some exploratory contributions [8]. While early works [8] looked at the needs of niche populations, we see a shift in recent discourse to focus on a broader user base, with researchers exploring how technology can fit into every home [1,2,4,5,9,11,12]. We see technology adapted to an array of uses in the kitchen, from improving knowledge and practices [2] to guiding the user, step by step, through the cooking process [9,12] to allowing the user to record and share their efforts with others [4]. We discuss these contributions and how they inform the task of working with recipes.

In Linda Mechling's review of interventions between 1986 and 2006 which aimed to teach cooking skills to individuals with intellectual disabilities [8], she highlights the potential of emerging technologies in cooking instruction. Her implications for technology and cooking instruction can be extended beyond her user group; namely the need to compare systems, explore new technologies, and to seek user preferences and social validation for systems.

When adapting technology for food education, we must ensure that the intervention has the intended effect. In Good Grubbin'[2], we see that having college students watch educational cooking programs to encourage healthy behaviours led to improved knowledge of healthy choices, but had no significant impact on behaviour. This suggests that providing high quality, easily accessed information may not be sufficient unless it aligns with existing user needs or goals.

CounterActive [5] represents early work along this line; it is an embedded interactive cookbook that aims to bring multimedia, like still images and video, into the cooking environment. Matching the interface design to the application resulted in a seamless integration of technology that allows users to focus on the task at hand. PersonalChef [9] took this concept further, allowing users access to instructional videos and on-demand information, suited to their culinary skill-level, while cooking from an unfamiliar recipe. Users enjoyed the interaction and expressed confidence in their ability to execute complex recipes with the help of the tool. Similarly, Panavi [12], a cooking system that guides users through complex recipes by providing situated instruction, shows the importance of creating technologies that provide information and instruction relevant to users' ever changing needs. These works implicitly acknowledge the weakness of the recipes found in cookbooks; it is difficult for unskilled users, or those exploring new recipes and cooking techniques, to execute static text instructions in the kitchen. In this study, we look more closely at how we might support the knowledge based challenges in cooking.

Moreover, we see that users are not interested in following instructions but are focused on results. They aim to create food which aligns with their expectations, rather than execute recipes verbatim. An interesting perspective on this is provided by Kristian J. Hammond with CHEF [3], which proposes a system which can collect, organize, and learn recipes in the domain of Szechwan cooking and then make recommendations to users based on their goals (tastes, textures, ingredients, and type of dish). This is the only study we found which uses the qualities of food, as users perceive them, as a metric for the interaction, which is key to our intervention.

A lack of food knowledge can be overcome with experience by adding new content to long-term memory [10]. The issue of computational overload, on the other hand, depends on working memory. Epistemic actions, alterations made to the environment for the purposes of aiding thought [6], contribute to making recipe modification easier. For example, a baker might portion out ingredients in advance and place them along with any needed tools in the work area. Changing things in the world frees working memory.

Our experimental interfaces build on these works, adapting technology and abstract food property information to support people trying to change recipes to suit their personal tastes. Through supporting user needs for information about outcomes as they perform recipe modification tasks, these interfaces remove a source of cognitive load from the user. The Enhanced recipe UI provides a more direct link between ingredients and techniques and AFPs, at the cost of being informationally dense. By providing users with the information they might need to make a change, the Enhanced recipe UI frees working memory to process AFP driven changes. Conversely, the informative real-time feedback in SAGE acts as an epistemic action, alleviating the cognitive load that accompanies computing the complex effects a given change has on a recipe.

DESIGN

Abstract Food Properties

In order to test the impact of abstract food properties on recipe modification tasks, our user study tests the ability of people to make alterations to a recipe for chocolate chip cookies with varying degrees of cookie related AFP information and presentation. To inform our work, we refer to The Food Lab: The Science of the Best Chocolate Chip cookies [7], which provides detailed descriptions of AFPs related to chocolate chip cookies and the ingredient and technique changes that can be used to alter them. The primary AFPs for chocolate chip cookies, according to López-Alt, are both taste and texture related, as outlined in Table 1, and are best conceived as continuous, opposing variables, like thick and dense vs. light and chewy. Given that chocolate chip cookies are a dessert, rather than a dietary staple, we do not use AFPs like healthiness or cost.

Using López-Alt's work, the resulting AFPs were categorized and linked to their affected ingredients and instructions. For our study we chose the ones that had high impact to the recipe and affected different variables at once (e.g. sugar impacted cookie chewiness, tallness, flavour and baking instructions). We removed changes that had minimal impact (e.g. type of chocolate only has effects on the resulting flavour). The goal was to study the effects of presenting usually hidden complex information to the user, and therefore ingredients with simple interactions and straightforward results were of no interest to the study.

PROTOTYPE

Three prototypes were developed to evaluate against each other. To reduce possible environmental confounds, all interfaces were developed for a tablet device. Interfaces were developed according to web usability standards, to facilitate reading and avoid eye strain.

The first, the "Plain Recipe" (Figure 1), is a non-interactive standard recipe, it uses a similar format and colour scheme as the other interfaces. This was done to avoid any confounds between technologies and any novelty effect. The Plain Recipe features ingredients and amounts in the top half of the screen, and instructions in the bottom half.

The second prototype developed is the "Enhanced Recipe", seen in Figure 2. It features a split design. The left side of the screen features a static recipe, identical to the Plain Recipe format. The right side shows expandable "Facts" which give textual explanations of expected results when changing ingredients or recipe steps, as well as outlining any interactions between ingredients or recipe steps.

SAGE (Figure 3) was developed as the third interface. In SAGE, the screen is again divided in two. The left side of the screen contains the same information provided in the plain recipe. The right side of the screen displays both visual and textual AFP information to users, as well as interactive elements which can be used to modify the AFPs of the recipe. When the user changes the value of a

AFP	Description
Crunchy vs. Tender	Textural. Cookies can vary widely in their crunchiness; from crunchy throughout to thoroughly soft, from crispy edges to chewy centers.
Dense vs. Light	Textural. Cookies can be heavy almost to the point of being brownie-like, or light and fluffy like sugar cookies or cake.
Smooth vs. Craggy	Textural and visual. Cookies can be smooth and uniformly textured, or they can have cracked, jagged surfaces and less uniform texture throughout.
Wide vs. Compact	Visual. A cookie can settle and spread during baking, providing a wider, thinner product, or they can remain taller with a smaller footprint.
Fudgie	Textural and flavour. Related to denseness, fudginess describes a texture more akin to a brownie; being both chewy, thick, and rich.
Nutty	Flavour. Without having nuts, certain ingredients can impart a nutty flavour to a cookie, like browned butter.
Buttery	Textural and flavour. In addition to having the flavour a butter, a buttery cookie has a more oily/fatty consistency to its texture.
Caramel	Textural and flavour. This refers to the toffee-like chewiness and flavour that caramelizing sugars can add to the bottoms and edges of a cookie.

Table 1: Abstract food properties used to describe chocolate chip cookies

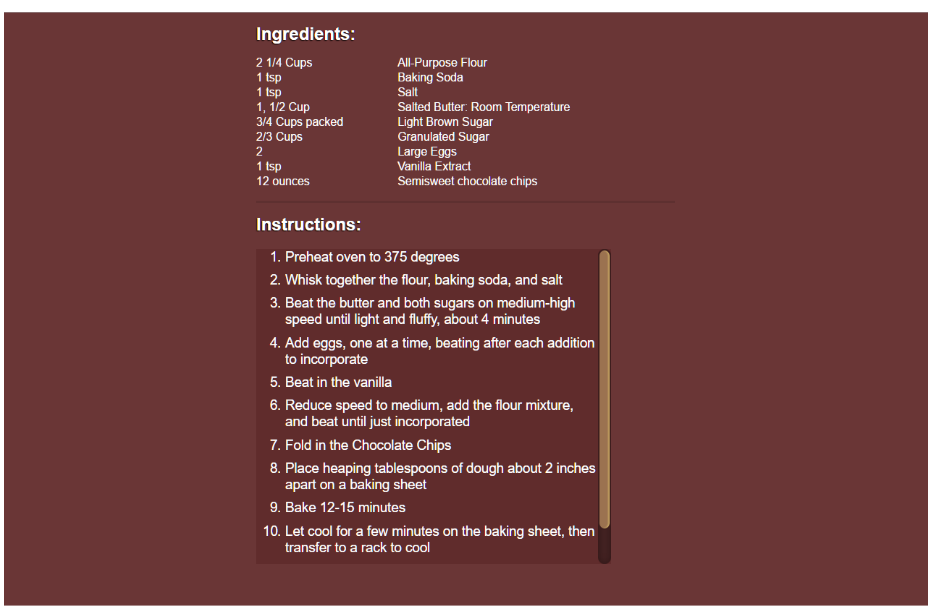

Figure 1: The "Plain Recipe" interface

Figure 2: The "Enhanced Recipe" interface

property, the ingredients, procedure, and visual representation are all updated accordingly. SAGE allows AFP modification in two ways. For AFPs that can be modified along a spectrum, a slider is used. For flavour, which does not fall along a spectrum, and is instead a set of discrete options, a styled radio button is used. Only one flavour can be selected at a time.

SAGE visualizes the last change made to an AFP which resulted in a change in the recipe. SAGE draws attention to these changes by highlighting altered text and numbers yellow. We also accompany the information changes with arrow icons, to indicate a positive or negative change with regards to its previous state. E.g. If the change requires more butter, an upwards arrow appears next to the butter quantity, as seen in Figure 3. To avoid overwhelming users with a variety of changes and colours, only the last change made is shown to the user. A description of the active AFP is included, using both text and representational diagrams to convey these abstract concepts and to ease information processing.

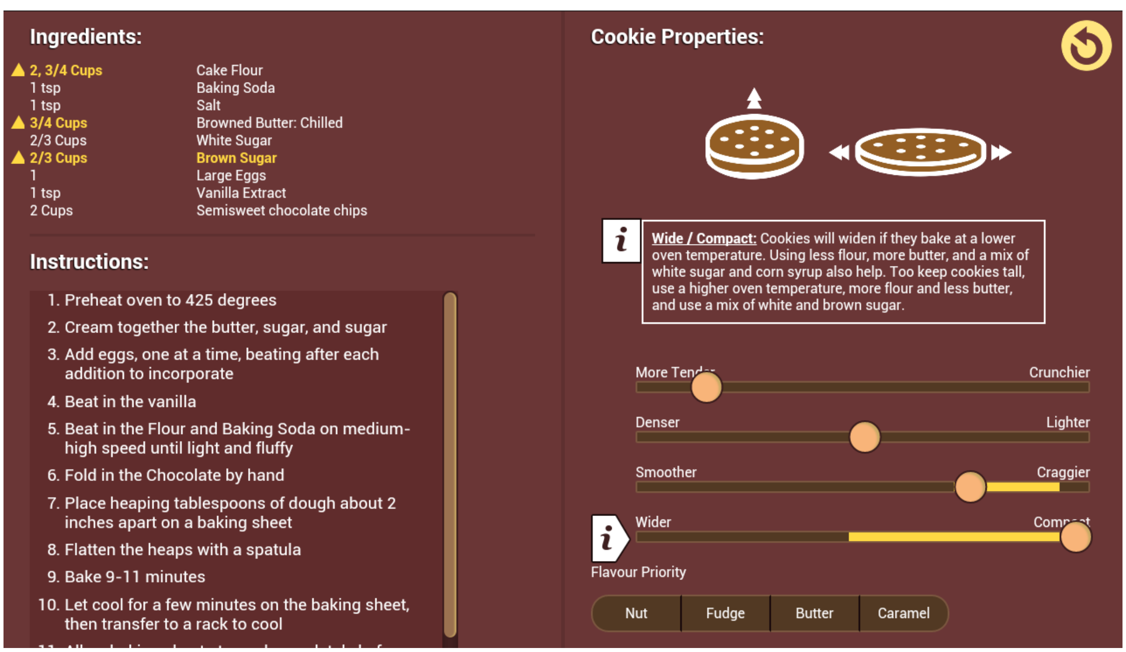

Figure 3: SAGE, showing some active modifications to a recipe

METHODOLOGY

Experimental Design

We performed a user study to evaluate the differences between the three interfaces. We created three hypotheses that would support our research questions. We predicted that providing AFP information would increase user confidence and ability to make changes to a recipe by reducing mental workload. Additionally, we proposed that displaying AFP information through directed representation would further decrease mental workload. Finally, we predicted that subjects would extract knowledge from visual interactions between UI elements, allowing them to add to their food knowledge.

We devised post-task surveys with the aim of measuring and comparing the impact of providing AFP information in various forms. We measured task load, confidence in successful task completion, and willingness to use the interface in the future in order to answer our research questions. Additionally, we were curious to see how user confidence in their ability to make changes, and their perception of how accurate those changes might be, changed based on the amount and presentation of information provided. This confidence measure is important because participants were not asked to prepare any cookies during the study. Similarly, we asked participants to rate how their understanding of the recipe and ingredient interactions changed during the task to ascertain if there is a learning or memorability effect from the experimental UIs.

Procedure

A within-subjects design was utilized. Participants completed five tasks in total, as seen in Table 2. The “Baseline” and “Post-Test” tasks were completed using the Plain Recipe.The UI conditions were a counterbalanced ordering of SAGE and the Enhanced Recipe, as shown in Table 2. Table 3 outlines the various cookie orders experienced by participants. Cookies were assigned to a label (A, B, C, and D), based on four recipe orderings as defined in Table 3. Randomization was used to account for any confounds that might arise from our cookie batches. Randomization was used over counterbalancing because we did not anticipate being able to recruit as many participants as would be needed for true counterbalancing.

	Randomized Recipe Orders				Label
Test Cookie Recipes	s1	s2	s2	s1	A
	s2	s1	s1	s2	B
	t1	t2	t1	t2	C
	t2	t1	t2	t1	D
Randomized Condition	1	2	3	4	

Table 2: Showing the four randomly assigned cookie orders used

	Counterbalance of experimental UIs		Cookies Used	
			Source	Target
UI Order	Baseline	Baseline	A	D
	Enhanced	SAGE	B	C
	Post test 1	Post test 1	C	B
	SAGE	Enhanced	A	D
	Post test 2	Post test 2	D	A
Testing Order	Condition 1	Condition 2		

Table 3: Schematic showing the cookie orders and counterbalancing used in the study

Prior to the study, participants completed a pre-survey assessing their food knowledge, food preparation experience, and familiarity with mobile devices. Following each task, a survey was administered which asked users to rate the source and target cookies based on the cookies’ AFPs, as well as to rate their experience performing the task using the interface. We measured confidence in task completion, perception of the amount of information provided relative to what was needed for the task, ease of making changes, usefulness of the layout of information, functionality of the interface for the task, and perception of whether or not learning occurred during the task. Additionally, we administered a NASA Task Load Index (TLX) to measure the difficulty of the task with the different UIs. After all the tasks were completed, participants completed an exit questionnaire assessing their overall experience and preferred interface.

During the experiment, participants performed a single task across all interfaces involving modifying a cookie recipe. Participants were provided with two quarter-pieces of cookie to sample, a “source cookie” and a “target cookie”, and a tablet displaying one of the three interfaces. Samples were prepared out of sight of participants. Participants were also provided with whole cookies for both the “source” and “target” for observation purposes. The initial state of eachinterface showed the recipe used to create the source cookie. They were asked to eat the cookie samples and describe their characteristics in terms of AFP values. Participants were asked to make changes to the instructions and ingredients such that, if the new recipe was followed, the target cookie would be produced. Participants were given pen and paper to write down their changes. For SAGE, participants were allowed to make changes on-device, but were still provided with pen and paper for any additional changes or changes they did not agree with. We baked four batches of cookies, each with differing AFPs (Figure 4) to be distributed throughout the tasks. All final recipes were achievable using SAGE.

Figure 4: The four batches of cookies used in the study

RESULTS

Participants

Participants were recruited using social media, emailing lists, and posters on a university campus. A total of 12 participants (3 female) were recruited. Participants range in age from their early twenties to mid thirties and vary in cooking experience from novice/no experience to very experienced. All participants have used mobile devices, reporting familiarity. All expressed moderate to high confidence in their ability to modify a recipe to taste. Two participants reported a dislike for chocolate chip cookies.Participants were counterbalanced across the two conditions, with 7 experiencing Condition 1 (Enhanced Recipe first, followed by SAGE), and 5 experiencing Condition 2 (Sage first, followed by Enhanced Recipe). A Mann-Whitney test for group homogeneity found one significant difference between groups ($p = 0.48$). Participants in Condition 1 rated themselves more likely to make mistakes while cooking than those in Condition 2. While we would expect this difference is due to our sample size, it requires that we take participant reports of their success on tasks with some caution.

Cookies

We gave participants cookies from four different recipes during the study. Participants' ability to successfully complete tasks was dependent on their ability to compare the cookies provided based on abstract food properties. Each participant was given a cookie from each recipe two to three times, depended on the randomized cookie order. We used agreement scores to determine if participants consistently described the cookies from each batch the same way. We found significant agreement scores from all but one user, with an average Cohen's Kappa of 0.34 (SD = 0.09), showing that, individually, users are able to describe cookies from the same batch in a consistent manner.

In order determine if cookies from the same recipe are described in the same way by all the participants, we calculated Krippendorff's alpha reliability estimate by comparing how each measured AFP was rated by each participant. Our resulting alpha, 0.24, is below the 0.5 threshold which would indicate that agreement amongst participants resulted from more than chance. This tells us that, while individually consistent, participants do not interpret the AFPs of cookies similarly. This individual consistency of perceived taste across cookie samples allows for significant results regardless of the subjective interpretation between subjects.

Comparing the Interfaces

Plain Recipe vs Experimental UIs

To answer our first research question, how the display of abstract food properties and associated information affects task performance, we first compare the Plain Recipe UI to the Enhanced and Sage UIs. We used a Wilcoxon Signed Ranks test to compare the user experience ratings of each interface and found that, on several factors the user interfaces that provide AFP information offered significant improvements, with an average medium effect size, over the Plain recipe task that followed each condition as shown in Table 4. The medium effect suggests that, in addition to being significant, there was a substantive difference in user experience between the Plain recipe and the UIs. The Plain Recipe did not outperform either interface on any measure. The performance of SAGE against the Plain recipe supports the idea that allowing recipe modifications using AFPs does improve user experience during a task. Similarly the comparison with the Enhanced UI illustrates that integrating information which connects ingredient changes and cooking processes to AFPs also offers gain in user experience. We compared the experimental UIs to the the baseline Plain recipe, but found no significant differences on any measure.

	Enhanced UI vs. Post Task		SAGE UI vs. Post Task	
	Effect Size (*r*)	Significance (*p*)	Effect Size (*r*)	Significance (*p*)
Confidence in task completion	0.13	0.522	0.40	0.048
Perception of adequate information	0.58	0.005	0.54	0.009
Ease of making changes	0.09	0.668	0.56	0.006
Useful layout of information	0.20	0.322	0.35	0.084
Functionality	0.22	0.271	0.20	0.339
Learning during use	0.61	0.003	0.59	0.004
Enjoyment of use	0.12	0.55	0.53	0.009
Likelihood of using UI again	0.20	0.339	0.54	0.008
Mental Load	0.03	0.888	0.52	0.011
Physical Load	0.41	0.046	0.14	0.48
Pace	0.08	0.68	0.25	0.227
Effort	0.17	0.391	0.43	0.036
Frustration	0.20	0.327	0.52	0.011
Success in task	0.02	0.905	0.40	0.048

Table 4: Showing effect sizes and significance of comparisons between the Plain Recipe post-tasks and the two experimental user interfaces, Enhanced and SAGE

Perceptions of Plain Recipe through Experiment

In order to see how user perceptions of the Plain recipe changed after exposure to the experimental UIs, we compared user rankings of each Plain recipe task as they were encountered: baseline, first post test, second post test. As shown in Table 5, we found that users were less likely to want to use the Plain recipe after exposure to the experimental UIs, and that after both experimental UIs had been experienced there was a significant increase in perception of difficulty when making changes to the Plain recipe.

SAGE vs. the Enhanced Recipe

Finally, we compared the two experimental UIs to answer our second research question: does the way AFP information is presented impact user performance. We used the Wilcoxon Signed Ranks Test and found significant differences in favour of SAGE. With Sage, the layout of information makes more sense, the interface is more enjoyable to use, it is perceived as easier to make changes to recipes, and reported mental load, effort, and frustration are lower than with the Enhanced UI. These significant results and their effect sizes are found in Table 6.

Baseline vs.Post Tests		
	Effect Size *(r)*	Significance *(p)*
Likelihood of using UI again decreased	0.54	0.008
Post Test 1 vs.Post Test 2		
	Effect Size *(r)*	Significance *(p)*
Ease of making changes decreased	0.42	0.038
Likelihood of using UI again decreased	0.43	0.034

Table 5: Effect size and significance for Plain Recipe comparisons between baseline, post test 1, and post test 2

	SAGE vs. Enhanced UI	
	Effect Size *(r)*	Significance *(p)*
Confidence in task completion	0.35	0.084
Perception of adequate information	0.24	0.234
Ease of making changes	0.55	0.007
Useful layout of information	0.49	0.016
Functionality	0.28	0.176
Learning during use	0.05	0.792
Enjoyment of use	0.52	0.011
Likelihood of using UI again	0.47	0.02
Mental Load	0.55	0.007
Physical Load	0.38	0.063
Pace	0.20	0.317
Effort	0.45	0.027
Frustration	0.44	0.033
Success in task	0.33	0.105

Table 6: Effect size and significance for comparisons between SAGE and the Enhanced Recipe

DISCUSSION

We anticipated that users would not be able to complete the initial Plain Recipe task. Surprisingly, most users actively tried to complete all tasks regardless of skill level. Interestingly, only one user gave up on a task: their final Post-Test. The user had done the modification test four times before the final task was presented, in which he gathered how to make an informed change to the recipe. He described the sample cookies to be substantially different from one another, but at that point had no confidence in the accuracy of his own knowledge to attempt any modification to the recipe. This offers interesting insight into the effect that the experimental UIs had on users. Much of the learning gained during use related to realizing how complex the baking process can be and how much information is required to modify a recipe to achieve any given abstract food property. We posit that users learned that they must employ a lot of information to be confident in their task success using the plain recipe, but that the specific AFP information available in the experimental UIs was not did not transfer in any substantial way to the post tests.

We find support for this in the experience reported by participants using SAGE. Participants tended to not look closely at changes being made until the end of the task. This mirrors the findings of Hammond's CHEF [3], which found that during cooking tasks people are results focused, and not interested in the steps in between except as a means to an end.

Participants expressed frustration with SAGE's functionality of only showing the last change made, and expressed a preference for an interface that shows all changes. This runs contrary to our expectation that users would not appreciate the added cognitive burden of having to process how the different AFPs contributed to the total changes made to the recipe, and suggests that participants perceive the AFP modifications using SAGE as a unified whole, rather than the sum of several contributing factors. An additional point to mention is that very few participants saw errors or omissions in SAGE's changes. Participants were provided with pen and paper to make additional modifications to the recipe while using SAGE, but very few made use of it.

Participants also struggled with the "Flavour" terminology used in SAGE (Figure 5). Many participants considered "Butter" and "Fudge" to be textures instead of flavours. Other participants expressed a desire for flavours not present in SAGE, such as "salty". Additionally, we observed that most users selected a flavour priority, even when they could not easily infer one from the cookies. Users did not realize that picking an option was not required. A solution would be to add a "None" option.

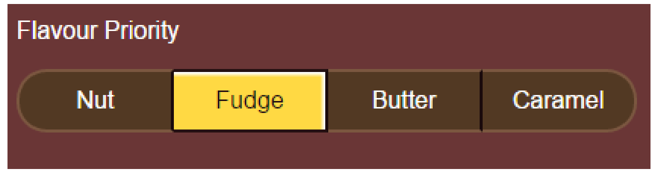

Figure 5: Flavour Priority selector as seen in SAGE

Participants generally preferred SAGE over the Enhanced Recipe because of its ease of use. As one user stated, "It appeals to my lazy side". Users generally did not look at the changes being made by SAGE until the end of the task. They were less able to glean food knowledge information, because SAGE shows only the last change made. By contrast, when using the Enhanced Recipe, participants read all relevant information before and while making changes. Those who preferred the Enhanced recipe did so for reasons such as "even though I felt overwhelmed, I felt like I had a better chance of achieving the target cookie with more information". This supports the findings of Good Grubbin' [2], in that highly detailed information can be useful, so long as it is directly suited to the user's current task. This confirms our second hypothesis, that direct representation of AFP information results in a lower mental workload compared to textual representation.

Both SAGE and the Enhanced Recipe seem to have unique benefits and drawbacks. The Enhanced Recipe leads to a more accurate result, at the cost of enjoyability. SAGE provides a more intuitive and enjoyable experience, at the possible cost of task accuracy and learning. A user's own desire to learn may impact which interface they would prefer in real usage. In our study, participants avoided reading or examining AFP information while using SAGE, preferring to trust the system's changes. This was true even for Condition 1 users, who would likely be aware that a Plain Recipe task would follow the SAGE task, having already experienced one experimental UI followed by a Plain recipe post test.

We do not believe that our study provided an accurate measure of the learning potential of the Enhanced UI or SAGE, making it difficult to confirm or deny our third hypothesis. While we found a significant learning effect for both experimental UIs compared to the Plain recipe tests, our participants reported that this amounted to learning how little they actually knew about baking cookies. This is consistent with our position that recipe modification is a complicated process that requires assistance. Due the the complex nature of the process, it may be possible to measure learning after repeated use of either experimental UI over a longer period of time. A modified protocol which would have participants bake cookies from their changed recipes might also show a more accurate learning effect.

Our first hypothesis was that providing AFP information would reduce mental workload, and increase user confidence and ability to make recipe changes. Compared to both the Plain recipe and the Enhanced recipe, we see that that mental workload was reduced using SAGE, and perceived ability to make changes did increase using SAGE. Confidence in successful task completion was found to only be significantly different between the SAGE UI and its post test. Counter intuitively, participants were more confident in their changes on the post test. Similar to the learning effect, we feel this is due a confound of users starting the study with a high "false confidence". As participants were presented with information and facts to which they had not been previously aware, we believe their original confidence decreased, but this decrease was offset by learning or interface assistance. A more accurate measure of real confidence would be needed to confirm these results. Users' initial false confidence might also be eliminated through having participants bake the cookies.

Future Work

We believe this study answered both of our research questions. We found that both the Enhanced Recipe and SAGE improved the process of modifying recipes through the display of AFP information. We also found that SAGE's presentation style of AFP information had several advantages over the Enhanced Recipe. However, our findings also raise several questions requiring further exploration.

Many participants struggled with SAGE's display of only their most recent change to the recipe. We suspect that participants learned less food knowledge when compared to the Enhanced Recipe, because they did not look at changes as they were being made. They expressed a preference for a version of SAGE which would show all changes made to the recipe. When we designed SAGE, we opted for the "last change" system to avoid overwhelming users with a variety of colours and indicators to separate changes made using the interface. It would be worthwhile to study whether adding a system to display all changes would allow users to more effectively increase their food knowledge, without impacting their ability to perform the task or their enjoyment. Alternately, implementing changes to the system which encourage users to pause and consider their adjustments may allow sage to better impart food knowledge during recipe modification.

One of the major critiques and comments about the Enhanced UI was its lack of order and categorization, many users described the interface as being "overwhelming", the information was purposefully presented as it was encountered in López-Alt's article. However, after hearing the criticisms from participants it is evident that an implementation of a filter, a categorization tool, or a search bar with tags, may eliminate many of the issues experienced by participants, making the information easier to access and use. This raises some questions: is a revised interactive solution still better at supporting recipe modification than a filtered, organized, and more accurately perceived text source? Will there be a difference in knowledge transfer between the two approaches, particularly over time?

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