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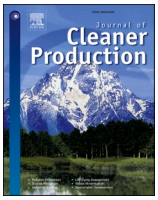

Convenient tools and social norms: Measuring the effectiveness of an intervention to reduce household food waste

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ABSTRACT

Halving food loss and waste is the target of the UN's Sustainability Development Goal 12.3, and household food waste constitutes a substantial part of global food waste. Effective interventions that decrease household food waste are urgently needed, and these could target various underlying behaviours such as planning, storing, preparing and consuming. There is a lack of studies that develop interventions based on theory and that compare different intervention options. Moreover, in testing the effectiveness of such interventions, possible influences caused by the measurement method need to be assessed. The current study explores two interventions, based on the Motivation-Opportunity-Ability framework, to test if combining a tool package (containing various waste-reducing tools such as a measuring cup, stickers, leaflets, recipes) with a motivational message based on social norms is more effective than the tool package alone. Additionally, it examines the effects of using a self-reported survey measurement for household food waste, to ensure that results are not caused by increased consumer awareness of food waste due to measurement alone. Findings show that the tool package significantly improves waste-preventing behaviours, and decreases self-reported food waste by 39.2% (experiment 1) and 23.0% (experiment 2). Effects on waste-preventing behaviours are stronger when social norm elements are added in the intervention. Results of the second experiment indicate that effects of self-reported measurement are minimal, which provides initial support for the use of self-reported food waste measurement in intervention testing albeit that underreporting remains an issue and more research is needed.

1. Introduction

Providing a growing population with enough nutritious food while decreasing the environmental burden is a wicked problem. To help accomplish this, reducing food waste is a key priority (Forbes et al., 2021). Food waste causes the unnecessary emission of greenhouse gasses and use of scarce resources, not only during production but also through transportation and packaging (Schmidt and Matthies, 2018). As a majority of food waste occurs in households (Forbes et al., 2021), effective interventions are needed that help consumers decrease the amount of food wasted at home. Yet, the design of effective interventions remains a challenge due to the complexities of food management at home. Multiple food management behaviours such as planning, storing, preparing and consuming, take place during which food is wasted (Quested et al., 2013).

Prior studies have shown promising effects for interventions that aim primarily at one stage of the food management process, such as fridge colour coding (Hebrok and Boks, 2017) or portion size monitoring (van Dooren et al., 2020). Yet, such studies are scarce (Simões et al., 2022) and, consequently, scholars have called for more intervention testing (Stöckli et al., 2018), especially for interventions with good theoretical underpinning (Reynolds et al., 2019). Moreover, a recent review of interventions regarding food waste prevention and composting shows that many interventions can be somewhat effective (Tian et al., 2022). Based on this, the authors advise the use of a variety of tools simultaneously, to achieve high-impact interventions. That is exactly what we set out to do.

To address the calls for more research, we test the effectiveness of a package that targets different stages of the food management process with various 'tools' such as stickers, leaflets, measuring cup, recipe cards. Drawing upon the Motivation-Opportunity-Ability (MOA) framework (Ölander and Thøgersen, 1995; van Geffen et al., 2020), we furthermore expect that the addition of motivational elements can

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improve the effectiveness of this intervention. The MOA framework claims that abilities, opportunities and motivations all need to be sufficiently present to spur behavioural change. Whereas the provision of various tools – through their very nature of tangible objects that help develop skills – directly address ability and opportunity barriers, motivational barriers may persist if not also addressed. The current study will therefore examine the addition of social norm messages in the intervention, to test if effects are stronger when this element is present as well.

In testing intervention effectiveness, we follow recent studies using a self-report measurement of household food waste (Cooper et al., 2023; van Lin et al., 2023; Schuster et al., 2022; Shu et al., 2023). Yet, such self-reported measurement may increase people's awareness about the food that they waste, and can in and by itself potentially decrease food waste (Reynolds et al., 2019). While increased salience of food waste has been often mentioned as a potential outcome of waste measurement (Sharp et al., 2010; Quested et al., 2020), empirical evidence for effects on behaviours and food waste provides mixed results: such effects have been detected in some studies (Langley et al., 2010; Nikravech et al., 2022), but not in others (Romani et al., 2018). Therefore, in a second experiment, we assess to what extent effects may be due to the self-reported measurement of food waste.

The next sections introduces the MOA framework and discusses prior evidence on the effectiveness of tools to decrease household food waste. Based on this evidence, the tool package intervention is constructed. The effectiveness of this tool package (with and without accompanying social norm messages) in changing household food management behaviours and self-reported food waste is tested in the first experiment. A second experiment uses a four-group Solomon design to disentangle effects of the tool package intervention from potential measurement effects. The results of these studies are useful for NGOs and policymakers who want to apply interventions to reduce household food waste, as well as for scholars who want to test the effectiveness of interventions.

2. Motivations, opportunities, and abilities

The Motivation-Opportunity-Ability (MOA) framework has recently been advocated as a theoretical lens in the context of household food waste (Soma et al., 2021; Van Geffen et al., 2020), and is also the organizing framework behind recommendations in the National Academies consensus report for a national US strategy to reduce food waste at the consumer level (National Academies of Sciences, Engineering, and Medicine, 2020). Its basic premise is that for behavioural change to occur, motivation, ability, and opportunity all need to be present to a sufficient degree (Ölander and Thøgersen, 1995). The MOA framework extends other frameworks, specifically the Theory of Planned Behaviour (Stefan et al., 2013; van der Werf et al., 2021; Visschers et al., 2016), by incorporating the context of food management behaviours as well as people's skills and knowledge to perform these behaviours. Despite the relevance of this framework, it is important to note that it is also possible to change consumer behaviour through changes in choice architecture, whereby motivation is not necessarily addressed (i.e., the "nudge" approach; Barker et al., 2021).

Food waste results from a complex set of behaviours that occur in the household (Quested et al., 2013), which have been categorized along stages of the food management process: planning, shopping, storing, preparing, and consuming (Roodhuyzen et al., 2017). Various tools (i.e., physical objects or digital applications that increase people's skills to reduce food waste) have been applied in prior intervention studies that address the behaviours in one or more of these stages. Although these stages do not need to follow each other chronologically, and can overlap, categorizing the food management process into these stages can clarify where interventions are likely to have effect. Table 1 provides an overview of published intervention studies to reduce household food waste. The table includes intervention studies with a pre/post design and/or a control group that have examined the amount of (reported or measured) food waste as a dependent variable. Only studies that measured food waste in the home quantitatively and statistically tested for differences are included.

Table 1
Overview of studies examining food-waste-reduction interventions.

Paper	Design	Intervention elements	Effects on food waste
Young et al. (2017) [a]	Intervention(s) vs individuals who did not remember the intervention (n = 2018)	Social media: newsletter, magazine, Facebook	Decrease (9–19%); similar between conditions
Shaw et al. (2018)	Two groups, pre/post (n = 60)	Leaflet with economic costs or environmental impacts	No significant differences
Romani et al. (2018) [a]	Solomon four group (n = 210)	Article about weekly menus	Decrease (29%)
Leverenz et al. (2019) [a]	Two groups, pre/post (n = 53)	Face-to-face vs online coaching sessions	Decrease >50% in both groups
Kim et al. (2020) [a]	Pre/post with control (n = 314)	Social marketing program with shopping bag, chopping board, recipe cards, shopping lists	Having hardly any fruit and vegetable waste increased after intervention (41%)
Pelt et al. (2020)	Three groups, pre/post (n = 64)	Knowledge provision vs awareness vs cognitive dissonance	Decrease in dissonance intervention more effective (33%)
Soma et al. (2020)	Three groups pre/post with control (n = 501)	Passive approach vs community engagement vs gamification	Decrease in gamification (30%), marginally significant from control
Van der Werf et al. (2021)	Pre/post with control (n = 112)	Tools: postcard, fridge magnet, freezer sticker, grocery list, food waste reduction tools, e-mails	Decrease (31%); significant from control
Wharton et al. (2021)	Pre/post (n = 53)	Information via website, podcasts, infographics, videos	Decrease (28%)
Roe et al. (2022)	Pre/post with control (n = 40)	Individually tailored coaching	Decrease (46.6%) not significant
Nikravech et al. (2022) [a]	Pre/post with control (n = 90)	Three-day long workshop in schools	Decrease in intervention (50–56%) and control (36–38%), not significantly different
Cooper et al. (2023) [a]	Pre/post with control (n = 1205 and n = 1047)	Program with use-up day, booklet, flexible recipes, app	Decrease (33%/46 %), significant from control
Shu et al. (2023) [a]	Two intervention groups pre/post with two control groups	Mailer with tips, refrigerator magnet, option to obtain a waste prevention pod. Second treatment group was additionally offered compostable liners and a discount on a composter.	Decrease (23%) in self-reported food waste versus an increase (29%) in control; decrease of inedible food scraps in curbside audit.

[a] Studies based on self-reported data using survey or diary.

As Table 1 shows, and in line with a recent meta-analysis (Tian et al., 2022), the most effective interventions are programs with extensive training and often one-on-one coaching (Leverenz et al., 2019; Roe et al., 2022). Such programs, however, are expensive to scale up and may reach only highly motivated consumers. At the other extreme, distributing a leaflet with general information about food waste appears to be

less effective (Shaw et al., 2018; Soma et al., 2020). Most interesting for the current study are the diverse tools that can diminish food waste (Kim et al., 2020; van der Werf et al., 2021; Shu et al., 2023). We take the advice of Tian et al. (2022), and examine a set of such tools in tandem. These tools are available at relatively low cost and allow easy scale-up.

Prior interventions studies have used tools that target different stages of the food management process, in different formats: information provision (e.g., storage advice on stickers; van der Werf et al., 2021), concrete instruments (e.g., measuring cups based on portions; van Dooren et al., 2020), and applications (e.g., recipe finders; Kim et al., 2020). Prior research also provides insights into which tools appear promising, and which appear less effective, such as the tools designed to increase the salience of leftover ingredients tested by Cooper et al. (2023). Overall, the provision of a set of waste-prevention tools that together cover the various stages of the food management process should improve consumers' perceived skills and knowledge (abilities). Based on prior research that has proposed behavioural change interventions to reduce food waste, we expect that the effect of the tools on food waste is mediated through changes in food management behaviours of consumers (i.e., that change in behaviours is the underlying process). We hypothesize:

H1. An intervention with a set of waste-prevention tools that target all food management stages increases (a) perceived abilities in food management of consumers and (b) their waste-prevention food management behaviours.

H2. An intervention with this set of tools decreases household food waste.

H3. The effect of an intervention with this set of tools on household food waste is mediated by food management behaviours of consumers.

Tools enhance people's skills and knowledge and may also improve the context in which food management is performed, which addresses the abilities and opportunities elements of the MOA framework. Yet, the third element of the framework – motivation –needs consideration too. Motivation is directed by the aim to achieve one's goals (Ölander and Thøgersen, 1995). At the core, people are aversive to wasting. They describe themselves as feeling guilty about wasting food (Quested et al., 2013) and forgo offers of additional food when this would be wasted (Bolton and Alba, 2012). Yet, because consumers often underestimate both the impact of food waste and the amount of food that they discard, and because consequences are neither imminent nor personal, food waste is unlikely to be a high priory goal for many people (van Geffen et al., 2020). Goals achieved within a shorter time horizon and with strong personal benefits, such as enjoyment or health, easily outweigh anti-wastage goals. Strengthening people's motivation to not waste could thus potentially increase the impact of an anti-food-waste intervention.

A promising way to increase people's motivation is through social norms. People have a tendency to conform to the behaviour of others, and social norm interventions can effectively change diverse behaviours related to sustainability (Schultz et al., 2007), including intentions to purchase suboptimal foods (do Carmo Stangherlin et al., 2020). In situations where many people perform an undesired behaviour (such as wasting food), giving attention only to descriptive norms that indicate the behaviour of others can backfire, and adding an injunctive norm element to signal social (dis)approval is advised to prevent this (Schultz et al., 2007). Messages that combine descriptive and injunctive social norm elements have been shown to have a larger effectiveness than only descriptive or only injunctive messages (Schultz et al., 2008). For such social norm messages that combine social (dis)approval with positive examples from the behaviour of others, we expect that:

H4. The effects of an intervention with both a set of waste-preventions tools and social norm messages that target waste-prevention on food management behaviours will be stronger than the effects of an intervention with only the set of tools.

H5. The effects of an intervention with both a set of tools and social norm messages that target waste-prevention on the amount of household food waste will be stronger than the effects of an intervention with only the set of tools.

Note that we do not expect the social norm messages to affect perceived abilities, as these messages do not provide any tips or information on how to diminish food waste.

3. Experiment 1: Effects of tool package with/without social norm messages

3.1. Method

3.1.1. Participants and design

Participants were recruited using an existing mailing list and social media announcements. The mailing list consisted of Dutch-speaking individuals who in previous years had participated in one of the studies conducted by the department (mostly in data collection for master student theses) and who had agreed to sign up and be informed of future studies. Participants were randomly assigned to a condition (tools ($n = 74$) vs. tools-plus-norms ($n = 76$)) of a 2-group design with pre- and post-measurement. They received an e-mail explaining the procedure and asking them to keep track of food waste in the household. Participants gave informed consent and the experiment was approved by the Ethical Committee of the university's social science department. As compensation, they received a free tool package and a gift certificate of 10 Euro was raffled among them.

Of the 166 participants who signed up, two did not fill in the first questionnaire, five dropped out, and nine did not respond to the second questionnaire, leaving a final sample of 150 participants (76.7% female; mean age of 40 years). Most of the participating households consisted of couples without children (41.5%) and couples with children (26.7%). The sample was relatively well-educated, with 44% having completed a university education.

3.1.2. Stimuli

Appendix A provides the contents of the package. Tools were provided by the Netherlands Nutrition Centre and contained their logo. The package was accompanied by a letter explaining that participants were free to use (or not) any of the tools in the package, that they would be asked about their food waste after two weeks, and that they could keep the tools after the experiment had finished. Participants in tools-plus-norms condition received two motivational messages with descriptive and injunctive norms, based on a fact sheet of the Netherlands Nutrition Centre, through e-mail (see Appendix B).

3.1.3. Procedure

The experiment took place in the Netherlands between November 18 to December 1, 2020. Participants filled in a questionnaire before and two weeks after the intervention. On both occasions, measures of food management behaviours, perceived ability, and self-reported food waste were included. To check that external circumstances did not change substantially during the experiment, we included questions about COVID-related circumstances (quarantine, eating at home, being at home during the day, doing groceries, and eating out), and found no significant differences between pre- and post-measurement (all $p > .15$). The questionnaires furthermore contained questions about socio-demographic background, participants' evaluation of the separate tools, their use of the tools, and (for the tools-plus-norms condition) whether they remembered seeing the e-mails containing social norm information (yes/no). Fig. 1 provides an illustration of the experimental procedure.

Recruitment	Participants are informed and give consent
Week 1	First survey (abilities, behaviours, food waste)
Week 2	Tool package sent to all participants (both conditions) First e-mail sent to participants in "tools plus norms" condition
Week 3	Use of tools Second e-mail sent to participants in "tools plus norms" condition
Week 4	Second survey (abilities, behaviours, food waste, evaluation of the tools)

Fig. 1. Timeline of experiment 1.

3.1.4. Measures

Perceived abilities were measured using 11 items, on a 7-point scale ranging from very bad to very good ($\alpha_{pre} = .80$ and $\alpha_{post} = .84$). Items cover all stages of the food management process and are based on prior research (Kim et al., 2020; Stancu et al., 2016). Food management behaviours were assessed as the frequency with which specific waste-reducing behaviours had been performed in the past week, using 13 items, on a 7-point scale ranging from never to always ($\alpha_{pre} = .80$ and $\alpha_{post} = .82$). Behaviours were selected based on prior research (Romani et al., 2018; Stancu et al., 2016; Stefan et al., 2013); see Appendix C.

Food waste was measured using an adapted version of the Household Food Waste Questionnaire (van Herpen et al., 2019) in which a few food categories were merged to diminish participant burden.[1] Participants first selected the food categories for which food waste occurred in their household in the past week, and for each selected category, they subsequently indicated the amount of food that was wasted in appropriate units (e.g., serving spoons, number of items, number of portions).

Participants provided an evaluation of each of the tools on items such as ease and pleasure (6 items; 7-point scales; average $\alpha = 0.81$) and were asked for potential improvements. Participants who indicated that they had not used a tool were asked for the reason in an open-ended question. Additionally, they indicated, in one item, the extent to which they currently engage in food waste reduction.

3.1.5. Data analysis

Repeated measures ANOVAs with condition as between-subjects factor and time (pre/post measurement) as within-subject factor examined effects on ability, food management behaviours, and amount of food waste. Table 2 indicates the effects that were tested and what these imply. PROCESS (Hayes, 2017) was used to examine the mediation of food behaviours for the relation between condition and food waste, based on difference scores (post- minus pre-intervention) for mediator and dependent variable. The PROCESS macro uses bootstrapping to obtain confidence intervals for the indirect effect of independent variable (condition) on dependent variable (food waste) through the proposed mediator (food behaviours). Our analysis used model 4 with 10,000 bootstraps (Hayes, 2017).

Table 2
Interpretation of the repeated measures ANOVAs.

Factor	Description	Hypothesis
Time (within-subjects factor, pre- versus post-measurement)	Intervention effect of the tools	H1, H2
Condition (between-subjects factor)	Difference between the tools and tools-plus-norms conditions across both pre- and post-measurement	Null effect expected
Interaction between time and condition	Whether the social norm messages increased the intervention effect	H4, H5

3.2. Results

3.2.1. Tool evaluations

Only 11 participants (7.3%) indicated to have not used any of the tools, and on average participants used 2.33 out of the six tools. With an average rating of 5.60 on a 7-point scale, they evaluated the tools that they used positively. The most often used tools were the measuring cup (66.7% of participants) and the shopping list (64.7% of participants). Appendix D provides further details about use and evaluation of specific tools.

3.2.2. Social norm messages

Only 41 out of 81 participants to whom e-mails with social norm messages were sent reported to have seen these messages. When we compared the participants that remembered seeing the e-mail ($n = 41$) to those that did not ($n = 40$), we found no significant differences in reported abilities, behaviours, nor food waste. We included all participants in the reported analyses (i.e., we examined the policy-relevant intention to treat effect).

3.2.3. Perceived abilities

A repeated measures ANOVA revealed that, in support of H1a, participants perceived higher ability after having received the tool package ($M = 5.66$) than beforehand ($M = 5.43$; $F(1, 148) = 25.67$, $p < .001$, $\eta_p^2 = 0.15$). The tool package thus successfully increased participants' perceived skills and knowledge, albeit to a modest extent, see Fig. 2. The main effect of condition ($F(1, 148) = 0.22$, $p = .643$) and the interaction between time and condition ($F(1, 148) = 2.54$, $p = .113$) were not significant. Follow-up analyses examining the stages of the food management process separately (Appendix E) show that this pattern is present across all stages, except that perceived ability to prepare meals in general did not increase due to the tool package (while perceived ability to estimate portion sizes did increase).

3.2.4. Food management behaviours

In support of H1, participants reported to perform more waste-reducing behaviours after having received the tool package ($M = 5.20$) than beforehand ($M = 4.69$; $F(1, 148) = 49.86$, $p < .001$, $\eta_p^2 = 0.25$). Furthermore, in support of H4, this effect was more pronounced when participants had received a social norms message, as shown by a significant interaction effect between time and condition ($F(1, 148) = 7.61$, $p = .007$, $\eta_p^2 = 0.05$; see Fig. 2). The main effect of condition was not significant ($F(1, 148) = 1.07$, $p = .303$). Follow-up analyses

[1] Specifically, we merged categories in which participants in a prior study (van Geffen et al., 2017) had reported, on average, less than 10 g of food waste in the period of one week together with a closely related category, when possible. This led the merging of non-fresh vegetables with fresh vegetables; non-fresh fruit with fruit; potato products with potatoes; fish and meat replacers with meat; cheese with yoghurt; crisps with candy. In addition, we merged the related categories of pasta and rice, even though the average grams per week wasted for rice was slightly higher than 10 g in the previous study (it was 12.02 g). Since the merged categories represented small amounts, we expect that any effect on overall reported food waste is negligible.

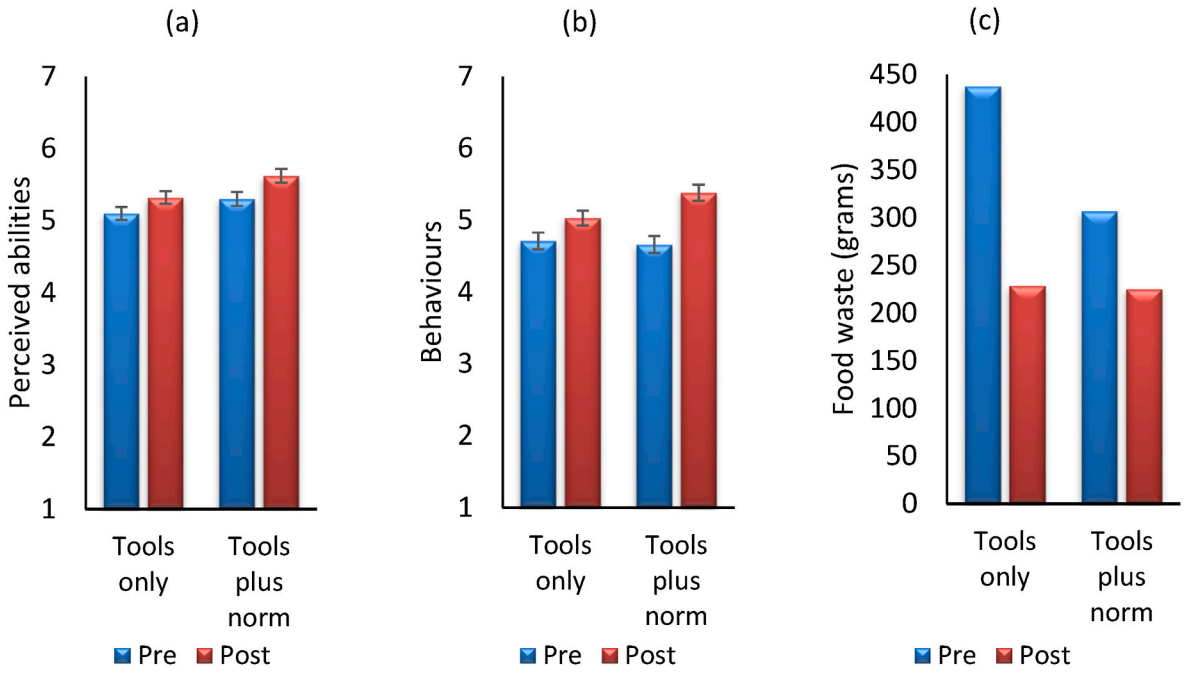

Fig. 2. Effects on (a) perceived abilities, (b) behaviours, and (c) food waste
Note: Standard deviations of food waste range between 289 and 484 g, which exceeds the boundaries of the graph and these are therefore not included in the figure.

examining the food management stages separately (Appendix F) revealed that the intervention effect was significant in all stages, and that the addition of social norm messages affected storage and preparation significantly (but not planning/shopping nor consumption).

3.2.5. Amount of food waste

In support of H2, the tool package successfully reduced food waste: average self-reported food waste before the intervention was 372.2 g per household per week, and after the intervention 226.60 g (a 39.2% reduction) ($F(1, 148) = 24.63$, $p < .001$, $\eta_p^2 = 0.14$). Furthermore, there was a significant interaction effect between time and condition ($F(1, 148) = 4.70$, $p = .032$, $\eta_p^2 = 0.03$), while the main effect of condition was not significant ($F(1, 148) = 0.72$, $p = .399$). The drop in food waste appeared to be higher in the condition where social norms were provided than in the tools-only condition, but follow-up analyses to examine the interaction pointed out that this is due to differences in baseline. These follow-up analyses showed that in both conditions the effect of the intervention was significant, and furthermore that food waste at the pre-measurement was marginally higher for the tools condition than for the tools-plus-norms condition ($F(1, 148) = 3.48$, $p = .064$), while these conditions did not differ after the intervention ($F(1, 148) = 0.004$, $p = .948$). This implies that the baseline measurements were (marginally) different, whereas both interventions brought food waste down to a similar low amount. This could be a floor effect, which impinges on our ability to get a clear assessment of the effect of adding the social norms messages.

3.2.6. Mediation

Mediation analysis showed that the effect of intervention type on differences in food waste was not significantly mediated by changes in food management behaviours (95% CI [-0.044; 0.154]. When examining the behaviours for each of the stages separately, results also showed insignificant mediation. Thus, the tool package apparently led to changes in food waste and to changes in food management behaviours, but we found no evidence that the changed behaviours were responsible for the decreased food waste.

3.3. Discussion of Experiment 1

Table 3 presents a summary of results. This experiment has shown that consumers perceive a modest improvement in abilities and report a change in household food management behaviours, as well as a decrease in food waste, after having received a tool package. Social norm messages enhance the effects on waste-reducing behaviours, although these do not decrease food waste further. That the social norm messages enhance effects on behaviours is surprising given that many participants reported not to have seen these, and indicates that such messages may be more effective than is apparent from this experiment. Although the tool package changes both behaviours and food waste, the mediation analysis indicates that the changes in behaviours did not cause the changes in food waste.

There is one important caveat in interpreting the results of this experiment: the repeated measurement of ability, behaviours, and food waste may have caused (part of) the effect, and the lack of a control group in this experiment prevents us from ruling this out. Due to social desirability (Elimelech et al., 2019), participants may have possibly exaggerated the change that took place. Self-reported food waste measurement has been described as "prone to bias and may overestimate actual behavior changes" (Simões et al., 2022). Empirical evidence for such effects, however, is scarce, with only tentative support for such an effect in a pilot study (close to marginally significant; Shu et al., 2021). To examine this possibility, a second experiment was conducted with a design that allows for comparisons with control groups.

Table 3
Summary of results, Experiment 1.

Expectations	Supported by the results
H1a: tools increase abilities	Yes
H1b: tools increase behaviours	Yes
H2: tools decrease food waste	Yes
H4: adding norms strengthens effect on behaviours	Yes
H5: adding norms strengthens effect on food waste	No

4. Experiment 2: Checking for a measurement effect

4.1. Method

4.1.1. Participants and design

To test for separate effects of measurement versus tool package, we used a Solomon four group design. According to this design, two factors were manipulated: whether participants were asked for a pre-measurement (yes/no) and whether they received a tool package as intervention (yes/no). The pre-measurement consisted of ability, waste-prevention food management behaviours, and self-reported food waste measures, which were asked prior to the intervention period for participants in the conditions in which the pre-measurement was present. Recruitment was done using a mailing list and social media, and all participants obtained a free tool package as reward for participation. Participants in conditions without intervention received this package after the data collection (including post-measurement) had been concluded. Participants in all conditions received an e-mail, explaining the procedure and asking them to keep track of food waste in order to provide accurate measurements. Participants gave informed consent and the experiment was approved by the Ethical Committee of the university's social science department.

Of the 300 participants who signed up, 14 did not fill in the post-measurement, one did not receive the full tool package due to a mishap in the postal service, and six participants who received a request to fill in the pre-measurement did not do so. This left 279 participants in the sample (78.1% female, mean age 46.4 years). Most of the participating households consisted of couples without children (34.4%), couples with children (26.9%), and single person households (20.1%). The sample was relatively well-educated.

4.1.2. Tool package

The tool package was identical to the first experiment, except for two changes. First, as the cooking app was hardly used in Experiment 1, it was dropped from the package. Second, a fridge thermometer had become available and was included to enhance the storage stage (see) Appendix A. No social norm messages were used in this experiment.

4.1.3. Procedure

The experiment took place in the Netherlands between March and May 2021. Appendix G provides an overview of the timeline. Filling in a questionnaire took between seven and 8 min on average.

4.1.4. Measures

Except for a few minor changes and added items, measures were the same as those used in Experiment 1 (details in Appendix C). Scale reliability was satisfactory (food management behaviours: $\alpha_{pre} = .81$, $\alpha_{post} = .80$; abilities: $\alpha_{pre} = .84$, $\alpha_{post} = .84$).

4.1.5. Data analysis

Focusing on participants in the two conditions that included a pre-measurement, we used repeated measures ANOVAs with tool condition as between-subjects factor and time (pre- versus post-measurement) as within-subjects factor to examine effects on ability, opportunity, and amount of self-reported food waste. As in Experiment 1, we use PROCESS (Hayes, 2017) to test for mediation through food management behaviours.

Next, using data from all participants, ANOVAs with presence of tools and presence of pre-measurement as factors were used to assess effects on food management behaviours and perceived ability. The distribution of self-reported food waste was highly skewed and contained many zeros (22.2%). To account for this, and consistent with previous studies on food waste (Lin et al., 2022; Qi and Roe, 2017; Visschers et al., 2016), we log-transformed non-zero measurements and used a Tobit model to assess effects of presence of tools and presence of pre-measurement. Table 4 describes the interpretation of the effects.

Table 4
Interpretation of the analyses in Experiment 2.

Factor	Description	Hypothesis
Repeated measures ANOVA on pre/post measurements (n = 136)		
Time (within-subjects, pre- versus post-measurement)	Effect of time across both tool and no-tool conditions	Possible measurement effect
Tool condition (between-subjects)	Difference between the two tool groups across both pre- and post-measurement	Null effect expected
Interaction between time and tool condition	Intervention effect of the tools	H1, H2
ANOVA/Tobit regression on post-measurements across all conditions (n = 279)		
Presence of pre-measurement (between-subjects)	Effect of the presence vs. absence of a pre-measurement	Possible measurement effect
Presence of tools (between-subjects)	Intervention effect of the tools	H1, H2
Interaction between presence of pre-measurement and presence of tools	Whether the measurement effect is stronger/weaker when tools were provided	Null effect expected

4.2. Results

4.2.1. Perceived abilities

Table 5 provides means and standard deviations. We first estimated a repeated measures ANOVA for the two conditions in which a pre-measurement was included (top part of Table 4). Results showed a significant main effect of time, with participants reporting a higher perceived ability in the post-measurement ($M = 5.55$) than in the pre-measurement ($M = 5.39$; $F(1, 134) = 11.93$, $p < .001$, $\eta_p^2 = 0.08$). This effect was qualified by a significant interaction between time and tool condition ($F(1, 134) = 7.92$, $p = .006$, $\eta_p^2 = 0.06$). Follow-up analyses showed that the difference in pre- versus post-measurement was not significant when no tools were provided ($p = .618$), while it was significant when tools had been provided ($M_{pre} = 5.37$, $M_{post} = 5.65$; $p < .001$). Thus, only when they had received the tool package did the perceived ability of participants improve, which is in line with H1 and results of Experiment 1. Follow-up analyses examining the stages of the food management process separately (Appendix H) showed a significant interaction in the preparation and consumption stages, indicating that the tool package was primarily effective in these stages.

Next, we compared the post-measurements across all conditions (bottom part of Table 4). Here, main effects of measurement (does the presence of pre-measurement affect abilities) and tool package (does the tool-package affect abilities) are of interest. The ANOVA showed a significant main effect of the presence of tools ($F(1, 275) = 7.51$, $p = .007$, $\eta_p^2 = 0.03$). The effect of pre-measurement ($F(1, 275) = 0.03$, $p = .854$) and the interaction effect ($F(1, 275) = 0.21$, $p = .649$) were not

Table 5
Means and standard deviations, post-measurements, experiment 2.

	With pre-measurement		Without pre-measurement	
	Tool package (n = 68)	No tool package (n = 68)	Tool package (n = 73)	No tool package (n = 70)
Food management behaviours (7-point scale)	5.37 (1.01)	5.16 (0.93)	5.37 (0.94)	4.89 (1.03)
Perceived abilities (7-point scale)	5.65 (0.82)	5.44 (0.72)	5.68 (0.74)	5.39 (0.83)
Food waste (grams per household per week)	274 (441)	388 (466)	267 (399)	241 (266)
Food waste (without outliers)	214 (246)	349 (342)	239 (324)	241 (266)

significant. Thus, we found support that the tool package changed perceived abilities, and no support for a measurement effect. Follow-up analyses for each stage of the food management process separately (Appendix H) showed that presence of a pre-measurement had no significant effect in any of the stages, while the tool package significantly affected planning/shopping, preparation, and (marginally) consumption.

4.2.2. Food management behaviours

Again, a repeated measures ANOVA was used to examine the two conditions in which a pre-measurement was included. Results showed that participants reported to perform more of the food management behaviours in the post-measurement ($M = 5.26$) than beforehand ($M = 4.96$; $F(1, 134) = 17.88$, $p < .001$, $\eta_p^2 = 0.12$), and that there was a marginally significant interaction with tool condition ($F(1, 134) = 3.13$, $p = .08$, $\eta_p^2 = 0.02$). Follow-up analyses indicated that the difference in pre- versus post-measurement was marginally significant when no tools were provided ($M_{pre} = 4.98$, $M_{post} = 5.16$; $p = .065$), while it was significant when tools had been provided ($M_{pre} = 4.94$, $M_{post} = 5.37$; $p < .001$). This indicates that the effects on food management behaviours may be somewhat due to being part of the experiment itself (i.e., measurement effect), while the tools had a strong effect. Follow-up analyses examining the stages of the food management process separately (Appendix I), however, showed that none of the interaction effects in these stages reached significance.

Next, we compared the post-measurements across all conditions. Results showed a significant main effect of the presence of tools ($F(1, 275) = 8.52$, $p = .004$, $\eta_p^2 = 0.03$). The main effect of the pre-measurement ($F(1, 275) = 1.31$, $p = .253$) and the interaction effect ($F(1, 275) = 1.34$, $p = .249$) were not significant. Thus, in these analyses we find support for the effectiveness of the tool package in changing food management behaviours (in support of H1), irrespective of whether a pre-measurement was taken (i.e., no measurement effect). Follow-up analyses examining the food management stages separately (Appendix I) showed no significant effects of measurement for any of the stages, and significant effects of the tool package for planning, consumption, and (marginally) preparation.

4.2.3. Amount of food waste

First, the repeated measures ANOVA revealed no significant effect of time ($F(1, 134) = 0.70$, $p = .405$) and a marginally significant interaction effect ($F(1, 134) = 3.13$, $p = .079$, $\eta_p^2 = 0.02$). Follow-up analyses indicated that the effect of pre- versus post-measurement was not significant when no tools had been provided ($p = .511$) and marginally significant when tools had been provided ($p = .068$; a decrease from 356 g per household per week to 274 g, or 23.0%). This provides tentative support that the tool package reduced food waste.

Next, to examine effects on the post-measurement of food waste for the whole sample, we ran a Tobit regression model in Stata. None of the effects were significant (main effect of presence of tools $p = .115$; main effect of pre-measurement $p = .158$; interaction effect $p = .569$). A possible reason is the high variability in reported food waste ($M = 291.5$; $SD = 401.3$), ranging between 0 and 2975 g per household per week. Inspection of the data indicated four outliers in the untransformed data, with values above 3SD from the mean. These may act as influential points, biasing the results. Removing these outliers resulted in a marginally significant main effect of the presence of tools ($\beta = -0.25$, $t = -1.77$, $p = .077$) and insignificant effects of pre-measurement ($p = .216$) and interaction ($p = .562$). This provides tentative support that the tool package could decrease food waste. Adding covariates (gender, age, household size) in the various analyses led to similar results.

4.2.4. Mediation

For the mediation analysis, we focused on households that provided pre-measurements to assess whether food management behaviours significantly mediated the effect of tool package on household food waste. Results showed that the effect of tools on differences in food waste was not significantly mediated by changes in food management behaviours (95% CI [-4.88; 23.49], and we also found insignificant indirect effects when testing the behaviours in each of the different stages, in line with the results of Experiment 1.

4.3. Discussion of Experiment 2

Table 6 summarizes the findings. Importantly, the tool package tends to decrease self-reported food waste compared to the baseline measurement, while no evidence for a measurement effect has been found. Comparing only the post-measurement across all conditions only showed this tendency after outlier removal, which may be due to the high variability in food waste amounts across the households. Intervention effects are easier to pick up when a baseline amount is taken into consideration for each household.

For perceived abilities, the tool package primarily affects consumers' ability to prepare food and consume leftovers. In the pre/post-tests for each of the different stages, we find some indications for potential measurement effects, but these are absent when looking at the overall effect on abilities in general and also do not appear when examining the post-measurement across all conditions. We therefore conclude that the tool package was able to increase perceived abilities, while empirical support for a measurement effect is weak.

For food management behaviours, we again find support for an effect of the tool package, but in this case the empirical support for a possible measurement effects is somewhat stronger. Although such a measurement effect is not significant when examining the post-measurement across all conditions, we find indications for such an effect in the pre/post-tests. We conclude that being part of the experiment and providing baseline food waste measurement is most likely to affect food management behaviours, but not actual levels of food waste.

5. General discussion

Providing the current and future world population with enough food is a big challenge, and the large amounts of food that is discarded, especially in households (Schmidt and Matthies, 2018) adds to this issue. To tackle this, there is a need for studies testing waste-reduction interventions (Stöckli et al., 2018) and examining whether self-reported measurements can indicate the effectiveness of such interventions. The current study set out to provide insights on both these issues.

First, our results provide insights on the effectiveness of an intervention that combines tools aimed at different stages of the food management process. Across two experiments, the tool package is indeed effective in increasing perceived abilities, increasing the targeted food management behaviours, and decreasing self-reported food waste (by 39% and 23%, respectively). Experiment 1 furthermore shows that social norm messages can enhance effects on food management

Table 6
Summary of results, Experiment 2.

Expectations	Supported in pre/post test ($n = 136$)	Supported in post-test ($n = 279$)
H1a: tools increase abilities	Yes	Yes
H1b: tools increase behaviours	Yes	Yes
H2: tools decrease food waste	Marginal effect	Marginal effect after outlier removal
Measurement effect on abilities	No	No
Measurement effect on behaviours	Marginal effect	No
Measurement effect on food waste	No	No

behaviours. This occurred despite that only half of the participants in the social norm condition reported to have actually seen the messages. Although the addition of social norms messages did not further decrease food waste in this experiment, this warrants further research attention. After all, social norm messages that are salient and attended to by consumers could potentially have stronger effects.

Second, our study provides insights about the measurement of intervention effectiveness for food waste. Experiment 2 shows indications for (relatively small) measurement effects, primarily on reported food management behaviours, but – importantly – not on self-reported food waste amounts. Thus, a single pre-measurement does not appear to greatly influence post-measurements. Repeated self-report measurements may have different effects though (see Cooper et al., 2023, for an example). Moreover, the current study does not investigate whether similar results would be obtained with direct measurement of household food waste (e.g., by compositional waste audits). A recent study by Shu et al. (2023) examined both self-reported survey measurement and a curbside waste audit, and showed that the survey trends were paralleled in the waste audit, which is reassuring first evidence. Further research is required, and waste audits are preferable when accuracy is a priority.

In Experiment 2, we note that while the pre/post comparison shows a marginal effect of the intervention on waste amount, analysis of the post-measurement across all conditions only shows this after outlier removal. We presume that this is due to the high variability in self-reported food waste amounts. This shows the relevance of pre/post assessments to control for this variation between households. Future research could further investigate the ultra-high wasting households. It may be that specific individual- and systems-level interventions need to be developed due to unique causes of this high waste. Likewise, it may be that targeting these individuals could play a currently unacknowledged role on food waste reduction.

A puzzling finding is the lack of mediation. While both behaviours and amount of food waste were affected by the tool package, the mediation analyses indicate that the decrease in food waste was not due to the change in behaviours that were measured. To measure food management behaviours, we asked participants to report how often they performed certain acts in the previous week. Upon reflection, it could be that not the frequency of performing the behaviours but the *thoroughness* with which these are performed matters, or *how* these are performed. Making a shopping list may be less important than sticking to the shopping list, planning meals in advance may be less important than following the plan, and checking inventory may be less important than adjusting shopping lists based on inventory. In addition, the relevance of certain behaviours can be interdependent. Planning meals in advance is less relevant for consumers who go on frequent shopping trips and can easily adjust meals. Preparing exact meal portions is less relevant for consumers who appreciate eating leftovers. The relation between food management behaviours and household food waste may be more complex than initially assumed.

5.1. Implications

The way consumers manage food in their households is strongly habitual (Quested et al., 2013) which poses a challenge for the development of behavioural change tools. Households' busy lifestyles require convenient tools that stimulate them to change routines, even when time is scarce. Prompts may play a role in behaviour change by visually reminding and stimulating change, and several of the tools (stickers, grocery list, measuring cup) could act as such prompts. Prior research (Tian et al., 2022) as well as our findings suggest that the use of a combination of tools focused on all food management stages is promising.

5.2. Limitations and future research

As the current study examined the effects of a set of tools that are provided simultaneously, we cannot disentangle which particular tool affected which behaviour. Future research could examine if, for specific segments of the population, greater amounts of food waste are linked to the various stages in the food management process, which would suggest a more targeted approach, in which certain tools are provided to certain types of consumers. In doing so, the cost-effectiveness of different tools could be taken into consideration as well. Some of the tools that were used the most by participants (e.g., the measuring cup) are relatively more costly than other interventions elements. Future research could also assess longer-term effects of the tools. Consistent use of the tools over time may be required to allow new behaviours to become routinized. What also needs to be taken into consideration is that the current research used non-representative samples. Reported results could be relatively strong because the samples may have included more involved consumers.

Although our second experiment suggests that a measurement effect is small or absent, that does not imply that our measurements of food waste are accurate. In fact, self-reported food waste is prone to (severely) underestimate the actual amount of food waste generated in households (Elimelech et al., 2019). Future research could be conducted with more objective measurements like waste audits to better assess the levels of food waste, and could also investigate causes for the difference between self-reported food waste and waste audits.

6. Conclusion

To reach sustainability targets, effective interventions that decrease household food waste are urgently needed. One such potential intervention, a tool package, has been examined in two experiments. The tool package targets various household food management behaviours, and results show that it can effectively decrease self-reported household food waste. Additionally, our study provides initial evidence that self-reported survey measurements can be used to assess the effects of food waste interventions without fear for strong measurement effects, although other limitations of such measurements (e.g., underestimation of food waste amounts) need to be kept in mind and more research is needed. Results also support the use of pre/post designs to test the effectiveness of interventions that aim to diminish household food waste.

CRediT authorship contribution statement

Erica van Herpen: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Tess Wijnen:** Conceptualization, Data curation, (Experiment 1), Formal analysis, (Experiment 1), Investigation, (Experiment 1), Methodology, Writing – original draft, Writing – review & editing. **Tom Quested:** Conceptualization, Methodology, Writing – review & editing. **Christian Reynolds:** Conceptualization, Methodology, Writing – review & editing. **Nikita Sharda:** Conceptualization, Investigation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Erica van Herpen reports financial support was provided by Dutch Research Council. Erica van Herpen reports equipment, drugs, or supplies was provided by Netherlands Nutrition Centre. Erica van Herpen reports a relationship with European Commission Joint Research Centre that includes: consulting or advisory. Christian Reynolds reports a relationship with Nutrition Scoiety that includes: board membership. Christian Reynolds reports a relationship with Institute of food science &

technology that includes: board membership. Advisory board for research projects, for Unilever, for Hello Fresh, and for EUFIC - Erica van Herpen Consulting for WRAP, DEFRA, and the FSA - Christian Reynolds Expert interviews/expert advisory group for Collider Lab, Fwd, Greener Beans, QUT Digital Media Research Centre, Haier Israel Innovation Centre, Almond Board of California - Christian Reynolds Speaker's stipend for the Folger Institute - Christian Reynolds Chaired panels/presentation for no fee at Nutrilicious and MyNutriWeb - Christian Reynolds Research funding from the Alpro Foundation - Christian Reynolds.

Data availability

Data will be made available on request.

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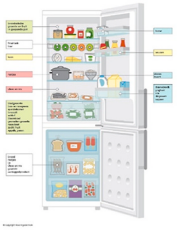
Appendix A. The contents of the tool package

Tool	Description	Stage of food management process	Picture
Shopping list	Notepad for making shopping lists	Planning	
Refrigerator sticker	Sticker that indicates which fruits and vegetables should be put in the fridge and which should not.	Storage	
Freezer sticker	Sticker indicating how long bread, leftovers, meat & fish, vegetables, and fruit can be kept in freezer.	Storage	
Reference to "bewaarwijzer" app	App that provides information on the shelf life of products.	Storage	
Leaflet about fridge use	Information on where (which area) to store specific products in the fridge for optimal shelf life	Storage	
"Eetmaatje" measuring cup	Measuring cup for various types of pasta and rice, indicating portions (amount for average person).	Preparation	

(continued on next page)

(*continued*)

Tool	Description	Stage of food management process	Picture
Leaflet on expiration dates	Information on the use of expiration dates (best before vs. use by)	Preparation	
Reference to cooking app[1]	App with recipes, focus on cooking with left-overs	Consuming	
Four recipe cards	Recipe cards for cooking from leftovers.	Consuming	 (one of the cards)
Fridge thermometer[2]	Thermometer to set the temperature of the fridge	Storage	

[1] Not included in Experiment 2.
[2] Only included in Experiment 2.

Appendix B. Social norm messages

Mail 1 (translation)

Nice that you are participating in the research on food waste; we hope that it is going well!

Besides you yourself, many other consumers are diminishing their food waste. In the Netherlands, 9 out of 10 households are motivated to reduce food waste. 80% of the Dutch have indicated that they are doing something against food waste. For example by planning their grocery shopping, cooking the right amounts, storing better, or eating leftovers. The Dutch find it important to not waste food, because they think that food waste is really not acceptable. Join these households by wasting less food yourself.

Good luck and enjoy the rest of the study.

Mail 2 (translation)

You are already half way through the study; hopefully the waste-free package is to your liking.

More and more Dutch households are starting to waste less food. Compared to 10 years ago, together we have already reduced the amount of food wasted by 29%. Of the Dutch population, 67% disapprove of food waste, because they think throwing away food is not acceptable. By also wasting less food yourself, you can contribute with other households toa waste free Netherlands.

In about one week you can expect the second and final survey. Could you fill this in as soon as possible after receiving it? We are very curious about your experiences!

Appendix C. Item formulation

Food management abilities. "How would you rate your food management skills for …" on a scale from very bad (1) to very good (7)	
planning meals	Planning/shopping stage
checking the pantry before shopping	Planning/shopping stage
making a grocery list	Planning/shopping stage
storing food properly	Storing stage
judging if food is still edible	Storing stage
understanding the expiry date	Storing stage
measuring portion sizes	Preparation stage
preparing meals[1]	Preparation stage
incorporating leftovers into other meals	Consumption stage
storing leftovers	Consumption stage
reusing leftovers	Consumption stage
preparing amounts that are just right[2]	Preparation stage
preventing leftovers[2]	Preparation stage
eating what has been cooked[2]	Consumption stage
Food management behaviour. "In the past week, how often did you …" on a scale from never (1) to always (7)	
make a shopping list prior to your shopping trip?	Planning/shopping stage
check your food inventories prior to your shopping trip?	Planning/shopping stage
avoid buying things that you already had in the pantry?	Planning/shopping stage
plan your meals several days in advance?[1]	Planning/shopping stage
check your fridge or pantry?	Storing stage
use food with limited expiry dates rather than food with extended expiry dates?	Storing stage
check the expiry date of food in the pantry?	Storing stage
eat all the food that had been prepared?	Preparation stage
prepare portions perfectly adequate for the actual needs of each family member?	Preparation stage
measure portion sizes?	Preparation stage
pay attention that there were as little as possible or no leftovers after the meal?[2]	Preparation stage
transform leftovers into different dishes rather than preparing completely new meals?[3]	Consumption stage
store leftovers in appropriate conditions so that they will last and be used properly?[3]	Consumption stage
try to eat leftovers?[3]	Consumption stage

Note: Stages not indicated to participants.

1 Not included in Experiment 2.

2 Only included in Experiment 2.

3 Only asked for participants who had indicated that there had been leftovers.

Appendix D. Tool use and evaluation

Tool	Use (number of participants)	Mean tool evaluation (SD)
"Eetmaatje" measuring cup	100 (66.7 %)	5.67 (0.89)
Shopping list note pad	97 (64.7 %)	5.70 (0.71)
Fridge and freezer sticker	71 (47.3 %)	5.62 (0.75)
Leaflets about fridge use and expiration dates	53 (35.3 %)	5.55 (0.81)
Recipe cards	19 (12.7 %)	5.63 (0.73)
"Bewaarwijzer" app	6 (4.0 %)	5.67 (0.88)
Cooking app	3 (2.0 %)	5.11 (0.98)

Appendix E. Effects on perceived abilities separated for each of the stages, experiment 1

	Pre-measurement		Post-measurement		Test of pre/post measurement	Test of intervention type	Test of interaction
	Tool package	Tool package plus social norms	Tool package	Tool package plus social norms			
Abilities overall	5.44 (0.77)	5.43 (0.85)	5.60 (0.76)	5.72 (0.79)	$F(1, 148) = 25.67, p < .001$	$F(1, 148) = 0.22, p = .643$	$F(1, 148) = 2.54, p = .113$
Planning/shopping	5.10 (1.21)	5.33 (1.17)	5.30 (1.14)	5.62 (1.12)	$F(1, 148) = 15.39, p < .001$	$F(1, 148) = 2.34, p = .128$	$F(1, 148) = 0.70, p = .406$
Storage	5.86 (0.74)	5.95 (0.81)	5.98 (0.75)	6.15 (0.75)	$F(1, 148) = 8.59, p = .004$	$F(1, 148) = 1.27, p = .262$	$F(1, 148) = 0.56, p = .456$
Preparation: determining portion sizes	4.46 (1.62)	4.21 (1.56)	5.03 (1.42)	4.91 (1.42)	$F(1, 148) = 37.59, p < .001$	$F(1, 148) = 0.68, p = .412$	$F(1, 148) = 0.40, p = .530$
Preparation: preparing meals	5.92 (1.08)	5.93 (0.93)	5.96 (1.09)	5.91 (1.02)	$F(1, 148) = 0.01, p = .924$	$F(1, 148) = 0.01, p = .905$	$F(1, 148) = 0.20, p = .654$
Consumption (leftovers)	5.52 (1.17)	5.23 (1.47)	5.58 (1.42)	5.61 (1.20)	$F(1, 148) = 6.90, p = .010$	$F(1, 148) = 0.46, p = .501$	$F(1, 148) = 3.69, p = .057$

Note: Because the items in the preparation stage were not highly correlated, we examined these separately.

Appendix FEffects on food behaviours separated for each of the stages, experiment 1

	Pre-measurement		Post-measurement		Test of pre/post measurement	Test of intervention type	Test of interaction
	Tool package	Tool package plus social norms	Tool package	Tool package plus social norms			
Food behaviours	4.71 (1.00)	4.66 (1.03)	5.03 (0.91)	5.38 (0.99)	$F(1, 148) = 49.86$, $p < .001$	$F(1, 148) = 1.07$, $p = .303$	$F(1, 148) = 7.61$, $p = .007$
Planning/shopping	4.71 (1.28)	4.91 (1.35)	5.04 (1.14)	5.36 (1.36)	$F(1, 148) = 17.13$, $p < .001$	$F(1, 148) = 1.92$, $p = .168$	$F(1, 148) = 0.48$, $p = .492$
Storage	4.74 (1.29)	4.50 (1.30)	4.90 (1.12)	5.24 (1.21)	$F(1, 148) = 17.10$, $p < .001$	$F(1, 148) = 0.09$, $p = .766$	$F(1, 148) = 7.17$, $p = .008$
Preparation	4.59 (1.37)	4.29 (1.41)	4.92 (1.29)	5.14 (1.31)	$F(1, 148) = 31.94$, $p < .001$	$F(1, 148) = 6.10$, $p = .015$	$F(1, 148) = 6.10$, $p = .015$
Consumption (leftovers)	4.81 (1.45)	4.86 (1.71)	5.24 (1.58)	5.77 (1.57)	$F(1, 148) = 23.87$, $p < .001$	$F(1, 148) = 1.73$, $p = .190$	$F(1, 148) = 2.96$, $p = .087$

Note. For participants who indicated not to have any leftovers, consumption of leftovers was assigned at 7 (highest point on the scale).

Appendix G. Timeline of Experiment 2

Condition	Between March 29 and April 6	Week of April 6	Between April 19 and April 26	Week of May 3
Pre/post plus tools	Pre-measure	Tool package	Post-measure	
Pre/post	Pre-measure		Post-measure	Tool package
Post plus tools		Tool package	Post-measure	
Post only			Post-measure	Tool package

Appendix H1. Effects on perceived abilities separated for each of the stages, experiment 2, pre- versus post-measurement

	Pre-measurement		Post-measurement		Test of pre/post measurement	Test of tool condition	Test of interaction
	Tool package	No tool package	Tool package	No tool package			
Abilities overall	5.37 (0.88)	5.42 (0.80)	5.65 (0.82)	5.44 (0.72)	$F(1, 134) = 11.93$, $p < .001$	$F(1, 134) = 0.39$, $p = .534$	$F(1, 134) = 7.92$, $p = .006$
Planning/shopping	5.52 (1.11)	5.44 (1.24)	5.73 (1.07)	5.50 (1.19)	$F(1, 134) = 3.75$, $p = .055$	$F(1, 134) = 0.72$, $p = .397$	$F(1, 134) = 1.08$, $p = .302$
Storage	5.98 (0.83)	6.02 (0.78)	6.18 (0.74)	6.07 (0.71)	$F(1, 134) = 6.02$, $p = .015$	$F(1, 134) = 0.80$, $p = .777$	$F(1, 134) = 2.17$, $p = .143$
Preparation	4.49 (1.55)	4.59 (1.25)	4.99 (1.46)	4.66 (1.18)	$F(1, 134) = 9.74$, $p < .002$	$F(1, 134) = 0.26$, $p = .612$	$F(1, 134) = 5.84$, $p = .017$
Consumption (leftovers)	5.47 (1.20)	5.56 (0.97)	5.72 (0.98)	5.53 (0.94)	$F(1, 134) = 2.58$, $p = .110$	$F(1, 134) = 0.10$, $p = .752$	$F(1, 134) = 4.37$, $p = .039$

Appendix H2. Effects on perceived abilities separated for each of the stages, experiment 2, post-measurement across all conditions

	No pre-measurement, no tool	No pre-measurement, tool	Pre-measurement, no tool	Pre-measurement, tool	Test of pre-measurement	Test of tool package	Test of interaction
Abilities overall	5.83 (0.85)	5.70 (0.73)	5.44 (0.72)	5.65 (0.82)	$F(1, 275) = 0.01$, $p = .939$	$F(1, 275) = 7.67$, $p = .006$	$F(1, 275) = 0.32$, $p = .571$
Planning/ shopping	5.33 (1.32)	5.95 (0.92)	5.50 (1.19)	5.73 (1.07)	$F(1, 275) = 0.26$, $p = .873$	$F(1, 275) = 9.76$, $p = .002$	$F(1, 275) = 2.03$, $p = .155$
Storage	6.10 (0.77)	6.10 (0.78)	6.07 (0.71)	6.18 (0.74)	$F(1, 275) = 0.06$, $p = .804$	$F(1, 275) = 0.36$, $p = .548$	$F(1, 275) = 0.36$, $p = .551$
Preparation	4.60 (1.40)	4.98 (1.16)	4.66 (1.18)	4.99 (1.46)	$F(1, 275) = 0.04$, $p = .835$	$F(1, 275) = 5.21$, $p = .023$	$F(1, 275) = 0.03$, $p = .853$
Consumption (leftovers)	5.49 (1.13)	5.71 (0.93)	5.53 (0.94)	5.72 (0.98)	$F(1, 275) = 0.07$, $p = .794$	$F(1, 275) = 3.01$, $p = .084$	$F(1, 275) = 0.01$, $p = .917$

Appendix I1. Effects on food behaviours separated for each of the stages, experiment 2, pre- versus post-measurement

	Pre-measurement		Post-measurement		Test of pre/post measurement	Test of tool condition	Test of interaction
	Tool package	No tool package	Tool package	No tool package			
Food behaviours	4.94 (1.12)	4.98 (1.01)	5.37 (1.01)	5.16 (0.93)	$F(1, 134) = 17.88$, $p < .001$	$F(1, 134) = 0.26$, $p = .614$	$F(1, 134) = 3.13$, $p = .079$

(*continued on next page*)

(*continued*)

	Pre-measurement		Post-measurement		Test of pre/post measurement	Test of tool condition	Test of interaction
	Tool package	No tool package	Tool package	No tool package			
Planning/shopping	4.96 (1.64)	5.11 (1.41)	5.27 (1.58)	5.25 (1.43)	$F(1, 134) = 4.20$, $p = .042$	$F(1, 134) = 0.08$, $p = .779$	$F(1, 134) = 0.60$, $p = .442$
Storage	5.09 (1.47)	5.15 (1.23)	5.33 (1.31)	5.26 (1.16)	$F(1, 134) = 3.24$, $p = .074$	$F(1, 134) = 0.00$, $p = .990$	$F(1, 134) = 0.44$, $p = .507$
Preparation	4.74 (1.55)	4.82 (1.45)	5.24 (1.44)	4.99 (1.20)	$F(1, 134) = 10.79$, $p = .001$	$F(1, 134) = 2.58$, $p = .110$	$F(1, 134) = 2.58$, $p = .110$
Consumption (leftovers)	5.04 (1.75)	4.91 (1.61)	5.66 (1.43)	5.19 (1.50)	$F(1, 134) = 11.54$, $p < .001$	$F(1, 134) = 1.74$, $p = .190$	$F(1, 134) = 1.74$, $p = .190$

Appendix I2. Effects on food behaviours separated for each of the stages, experiment 2, post-measurement across all conditions

	No pre-measurement, no tool	No pre-measurement, tool	Pre-measurement, no tool	Pre-measurement, tool	Test of pre-measurement	Test of tool package	Test of interaction
Food behaviours	4.89 (1.03)	5.37 (0.94)	5.16 (0.93)	5.37 (1.01)	$F(1, 275) = 1.31$, $p = .253$	$F(1, 275) = 8.52$, $p = .004$	$F(1, 275) = 1.34$, $p = .249$
Planning/ shopping	4.68 (1.68)	5.52 (1.45)	5.25 (1.43)	5.27 (1.58)	$F(1, 275) = 0.77$, $p = .381$	$F(1, 275) = 5.51$, $p = .020$	$F(1, 275) = 5.02$, $p = .026$
Storage	5.07 (1.25)	5.49 (1.27)	5.26 (1.16)	5.33 (1.31)	$F(1, 275) = 0.02$, $p = .887$	$F(1, 275) = 2.68$, $p = .103$	$F(1, 275) = 1.39$, $p = .239$
Preparation	4.77 (1.38)	5.08 (1.31)	4.99 (1.20)	5.24 (1.44)	$F(1, 275) = 1.48$, $p = .225$	$F(1, 275) = 3.00$, $p = .084$	$F(1, 275) = 0.03$, $p = .866$
Consumption (leftovers)	5.08 (1.70)	5.48 (1.36)	5.19 (1.50)	5.66 (1.43)	$F(1, 275) = 0.62$, $p = .432$	$F(1, 275) = 5.96$, $p = .015$	$F(1, 275) = 0.04$, $p = .841$

Note. For participants who indicated not to have any leftovers, consumption of leftovers was assigned at 7 (highest point on the scale).

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