sustainability

MDPI

Article

Nudging Householders to Reduce Avoidable Food Waste: The OzHarvest Use It Up Tape

Mark Boulet * and Nita Lauren

BehaviourWorks Australia, Monash University, Clayton, VIC 3800, Australia
* Correspondence: mark.boulet@monash.edu

Abstract: Targeting households with food waste reduction interventions represents a critical opportunity to meet global targets to halve food loss and waste. While the evidence base on the effectiveness of food waste interventions is growing generally, less is known about the outcomes of household-focused interventions. This mixed methods study explores how households experienced a behaviourally orientated nudge (the OzHarvest Use it Up Tape™) and examines its impact on food waste and behaviour change. The "Tape" served multiple functions for households—including as a visual prompt, a labelling device, a planning tool, and a communication tool—and was more effective for large families and for individuals who were disorganised when shopping and cooking. Significant reductions were also identified in participants' fresh vegetable and fruit waste and in the total food amounts they wasted. This study demonstrates the effectiveness of behaviourally orientated nudges, like the Tape, in reducing food waste.

Keywords: food waste; behaviour change; interventions; nudges; households

check for updates

Citation: Boulet, M.; Lauren, N. Nudging Householders to Reduce Avoidable Food Waste: The OzHarvest Use It Up Tape. *Sustainability* **2024**, *16*, 5132. https://doi.org/10.3390/su16125132

Academic Editors: Ping Dong and Long Yu

Received: 30 May 2024
Revised: 13 June 2024
Accepted: 14 June 2024
Published: 17 June 2024

1. Introduction

The turn of the century has seen a substantial increase in policy and research attention to the global food waste challenge and the urgent need to reduce waste and loss across the entire food system (see, for example, [1–4]). The diverse and severe social, economic, and environmental impacts from food waste have led to the inclusion of target (12.3), to halve global food loss and waste by 2030, in the United Nation's Sustainable Development Goals [5]. While waste and loss occur at all stages (from production to consumption) of the food system, over 900 million tonnes are wasted each year worldwide in the consumption stage (retail, hospitality, and households) alone, with household food wastage representing around 60% of this amount in most countries [3]. The consumption stage, with households as a key target, therefore represents a critical area for effective food waste reduction policies and programs.

A 2019 review [6] of food waste reduction or prevention interventions at the consumption stage by Reynolds and colleagues identified only 13 studies with quantified waste reduction outcomes. Of these, just six tested the impact of interventions targeting the household. Reynolds et al. [6] argued that this small number of studies represents a significant gap in the evidence base relating to food waste reduction interventions, and it was therefore difficult for policy and program managers to "make evidence-based decisions to prevent or reduce consumption stage food waste in a cost-effective manner" [6] (p. 1). They concluded their review with a plea for more "well-designed [food waste] interventions . . . [that are] tested using carefully selected methods to understand the outcomes of the intervention and how it works (or not)" [6] (p. 20).

Pleasingly, in the years since Reynolds et al. [6] published their review, there has been a small explosion of published studies exploring and measuring the impacts of food waste reduction interventions at the consumption stage. Studies such as [7–9] have measured the outcomes of broad-based multi-faceted campaigns that combine different

consumer engagement approaches, while others [10–12] have measured the outcomes of more targeted interventions, such as food waste reduction tool kits, flexible recipes, and targeted messaging to consumers.

This greatly expanded evidence base has led to further systematic reviews that collate different food waste reduction interventions at the consumption stage and synthesise their outcomes [13–15]. Simões et al. [13] for example, reviewed 96 studies and identified 18 which specifically engaged consumers in reducing food waste from their households. Most of the interventions in these studies were focused on raising consumers' awareness of food waste impacts and providing information on how to reduce or avoid waste. While [13] acknowledged that providing consumers with this type of information was important, they argued that it is often not enough to encourage consumer behaviour change and it needs to be complemented with other intervention types, such as the provision of tools or changes to the home or food retail environments.

A more recent meta-analysis [15] looked at the effectiveness of nudge-based interventions in addressing food waste at the consumption phase. Defining a nudge as "a voluntary, non-intrusive intervention that induces behavioural changes without economic incentives or mandates" [15] (p. 1), they compared the effectiveness of cognitively orientated (changing attitudes, awareness, and knowledge) and behaviourally orientated (modifying the environment in which behaviours occur) nudges. Their meta-analysis revealed that while nudges overall can have a significant effect on reducing food, behaviourally orientated ones are generally more effective in reducing food waste than those that are cognitively orientated (despite the latter being more commonly used in policy and practice). This review [15] highlights the value of nudges in reducing food waste, and echoes a point made by [13] that the evidence base on the effectiveness of nudges and other interventions to reduce food waste in households is still relatively limited (compared to that in other settings, such as hospitality or education institutions).

Our paper aims to strengthen the current evidence base by exploring how households experienced a behaviourally orientated food waste reduction nudge trialled in Australia, and examining its impact on both food waste reduction and behaviour change.

Intervention Development

Founded in 2004, OzHarvest (Website: https://www.ozharvest.org/, accessed on 1 June 2024) is one of Australia's leading national food rescue charities. It has recently complemented its food rescue and education focus with campaigns that engage Australian consumers and households in reducing avoidable food waste. Drawing on previously commissioned research that identified and prioritised food waste reduction behaviours for the Australian context [16], OzHarvest targeted a key behaviour that was considered to be the most impactful (in terms of reducing food waste) and relatively easy for households to apply, namely: householders preparing a regular 'use it up' meal that combines any food in the refrigerator or pantry that needs to be used up (this includes leftover meals and ingredients, as well as items nearing their use-by-date).

To engage Australian households in this behaviour, and in food waste avoidance more generally, OzHarvest developed the Use It Up™ campaign (Website: https://www.ozharvest.org/use-it-up/, accessed on 1 June 2024). As part of the campaign, the Use It Up Tape™ (Website: https://events.ozharvest.org/shop/viewitem/use-it-up-tape, accessed on 1 June 2024) (see Figure 1) was created as a tool to make it easy for householders to adopt the target behaviour. The initial idea was that the brightly coloured product could be used to mark out a space in the refrigerator or pantry to create a 'Use It Up shelf' on which items that needed to be used up could be placed [16]. First made available to the Australian public in October 2021, over 95,000 units of the Use it Up Tape ("the Tape") have been delivered nationally since that time. Under a licensing agreement, an equivalent version was created for The Netherlands ('Eerst Op Tape') and distributed to 40,000 Dutch households. OzHarvest is currently in conversation with other countries about developing additional local versions.

Figure 1. OzHarvest Use It Up Tape™.

The Tape (and the shelf space it created) was expected to function as a *visual prompt* to remind householders (when they opened the refrigerator or looked in the pantry) of food items or leftover meals that needed to be eaten before they spoiled or before new ones were purchased. Visual prompts are behaviourally orientated nudges that make desired behaviours salient in the minds of individuals [17,18]. It is well established (see, for example, [19,20]) that there are a number of cognitive constraints that prevent individuals from paying active attention to every behaviour (and its implications) that they engage with throughout any given period. This limited attention has been suggested as one of the reasons for the gap between an individual's behavioural intentions (such as using up food items in a meal) and their final actions; commonly known as the intention–action gap [17,21]. Visual prompts such as the Tape and the messages contained on it (e.g., "Eat me", "Cook me up", etc) can help to close this gap by 'nudging' the individual to first recall their intention to use up particular food items before they spoil and to then action this intention by making a meal from these items.

This paper presents a mixed methods intervention impact study of the Tape as a behaviourally orientated nudge to reduce food waste. It describes the design and outcomes of two complementary studies conducted in Australia which explored how households used, and experienced, the Tape, and examined its impact on food waste and on relevant household food provisioning behaviours. The remaining sections of this paper present the methods and results for each study, discuss their findings and implications for food waste policy and programs, and suggest future research opportunities.

2. Materials and Methods

The use and impact of the Tape was explored through two complementary studies:

1. A qualitative observational study that utilised participant-made video diaries to explore how the Tape was used and experienced by different households.
2. A quantitative pre–post study in which participants completed a validated survey-based tool to report their food waste amounts before and after a two-week period of using the Tape.

Each study is described in greater detail below. Taken together, they give insights not just into the food reduction impacts of the Tape, but also its suitability for different households and its different functions to support household food provisioning and reduce waste.

2.1. Study 1

This study is a qualitative observational one, with video diaries used as the primary data collection method. The diaries visually capture participants' use of the Tape and prompt detailed reflection of their experience with it. Video diaries bring the researcher

one step closer to the reality of participants' lives and capture what actually happens in situ rather than the more general and abstracted insights that can come from surveys and interviews [22,23].

Research ethics approval was given by the Monash University Ethics Committee (project ID # 28967).

2.1.1. Research Participants

A specialist market research company was engaged to assemble a panel of participants who were financially incentivised (a small stipend) to take part in this research. Panel members are trained in smartphone video recording techniques and upload videos for researcher access to an online platform maintained by the company.

The participants (n = 9) in this study were low to middle-income earners from a mix of regional and metropolitan locations along the Australian west coast, primarily around the Western Australian city of Perth (see Table 1). They were the main person in their household responsible for cooking and shopping, their ages ranged from 25–60 years, and they came from households with and without children.

Table 1. Description of qualitative study participants (n = 9).

Demographic		Number of Participants
Gender	Female	5
	Male	4
Age	21–30 years	1
	31–40 years	4
	41–60 years	4
Number of children in household	No children	6
	1–2 children	1
	3–4 children	2

2.1.2. Research Protocol

Participants were sent a roll of the Tape and provided with basic instructions for its use (mainly that its goal was to help remind them of which food needed to be used up, and that it could be used to mark out a shelf in their refrigerator or pantry). During a two-week period of using the Tape, they were asked to record up to five short (five to ten minute) videos, including:

1. A set-up video showing how the Tape was first used, their initial reflections and their intentions for the next two weeks.
2. Up to three check-in videos (spaced two to four days apart) that showed how the Tape was being used, changes in its use since set up, its general performance and influence on their shopping or cooking practices, and how other household members have interacted with it.
3. A final reflection video on their overall impressions of the Tape, its influence, impacts and outcomes, what changes they might recommend and whether they intend to keep using it.

While the Tape's aim of supporting households to use up leftover meals and ingredients was openly and clearly communicated to participants, the focus on food waste reduction or avoidance was made less explicit. This was to avoid potentially biasing the responses due to perceived social norms against being wasteful with food.

2.1.3. Data Analysis

We received four to six videos from each participant, with a total of 43 videos across the entire sample. Two types of data emerged from this research design: (i) the video recordings of the participants, their refrigerators, pantries, and food, and (ii) their audio transcripts

when responding to the prompts above. We were primarily interested in participants' reflections, perspectives and self-reports while recording their video diaries. The audio transcripts were therefore the focus of our analysis, while also noting what we could see of the Tape and its use when it was shown by participants.

We conducted a mainly deductive thematic analysis of the audio transcripts, in which common themes within an individual's video diaries, and across different participants diaries, were noted [24,25].

2.2. Study 2

The second study aimed to quantitatively measure the food waste reduction potential of the Tape and to understand which household food-related behaviours it supported. Following a pre–post trial approach, a validated food waste self-measurement survey was completed by participants before and after they used the Tape for two weeks, and food waste outcomes at each stage were compared.

This study was given ethics approval by the Monash University Ethics Committee (project ID # 32508)

2.2.1. Research Participants

OzHarvest promoted the Tape mainly through its website and extensive social media network (Facebook, X (formally Twitter), and Instagram). This promotion highlighted the potential food waste reduction benefits of the Tape and directed people to the OzHarvest website to order it. While ordering, anyone living within Australia was then invited to participate in the study. No incentives were provided for participation, although at the time of the study, the Tape was made available for free (only postage needed to be paid).

361 participants completed the pre-use survey, and 144 participants completed the post-use survey, with 76 of these participants having fully completed both pre- and post-use surveys ('matched pairs'). A demographic summary is presented in Table 2, which shows that the sample tended to be around 50 years old and most identified as female.

Table 2. Demographic summary of both the entire sample and matched pairs for the quantitative study.

	Entire Sample	**Matched Pairs**
Age (average)	49.74 years	52.10 years
Gender	88.9% identified as female	93.2% identified as female
Household size	31.9% had 4 people	31.5% had 2 people
Number of kids in household	46.5% had no children	49.3% had no children
Education	29.9% had undergraduate degree	28.8% had undergraduate degree
Employment	38.9% were employed full time	26% were employed full time

2.2.2. Research Protocol and Survey Measures

When ordering their Tape from the OzHarvest website, those willing to participate in the study provided their email address and were emailed a link to the pre-survey to complete immediately. At the same time, the Tape was posted to their homes. Within three weeks of the Tape being sent to a participant, they were emailed the link to the post-use survey. With potential delays in postal delivery and participants using the Tape, it was assumed that this period would enable participants to use the Tape for about two weeks overall before completing the post-use survey.

When completing both surveys, participants were asked to provide the four-digit postcode of the Australian suburb where they usually live and their birthdate (i.e., DDMMYY). These two number sets were combined in the analysis to give each participant a unique code, which was used to match their pre- and post-use survey responses (if both were completed).

Both pre- and post-use surveys measured participant food waste based on the Household Food Waste Questionnaire (HFWQ) approach developed—and validated for European countries—by [26], and later refined by [27] for the United States. This asks participants to first identify the different types of food that they discarded and then estimate how much of each type was discarded. Both pre- and post-use surveys took about 10 min each for participants to complete online.

For the first part of each survey, participants reviewed a list of 24 food and drink categories and ticked each category that they had discarded over the past seven days. They were asked to include any edible food and drink they bought online, at the supermarket, as takeaway, or grew themselves, as well as meal leftovers or products that were spoiled or past their expiration date. Bones, peels, pits, or cores, or food and drink thrown away when eating out of the home were not included. Participants were asked to include any food or drink regardless of how it was disposed (i.e., in the bin, compost, or given to pets).

The second phase of the survey asked participants to estimate how much of each food and drink type they discarded, but only for those categories that they had identified previously. We followed [27] and used 'cups' as the more appropriate unit for an Australian audience to estimate how much was thrown out. We also used 'portions', 'pieces' or 'glasses' as other relevant units for different categories (e.g., for fruit, snacks, or beverages, respectively). As per [27], participants were given further guidance to estimate how much of each category they discarded (e.g., "A cup of rice equals 153 g" or "A portion of meat (150 g) refers to one chicken breast, one steak etc"). To reduce survey time and ensure response quality, we did not follow [26] or [27] by asking participants to nominate the 'status' of discarded food (i.e., "completely un-used", "partly used", "meal leftovers"), as this was not critical to the aim of quantifying food waste amounts.

Finally, participants indicated (on a five-point ordinal response scale from "never" to "always") the frequency with which they performed certain household food provisioning behaviours (e.g., checking food stocks before shopping or making a meal with food that needs to be used up). Behaviours included here were not just the target behaviour for the Use It Up campaign described previously, but also included behaviours that were mentioned by participants in Study 1 as something they did because of the Tape.

2.3. Data Analysis

The total quantity of self-reported food waste for each participant was calculated by translating the waste unit for each category (e.g., "cups", "portions") into grams and summing across all categories. Here, we followed the table of average weights for each food and drink category used by [27], which in turn are based on the US Department of Agriculture's estimates for different food categories. Assumptions of normality were tested prior to analysis, where the skew and kurtosis of each food waste category and food provisioning behaviour were checked. The data was considered normal when skew values were between −2 or +2 and kurtosis was between −7 and +7 [28].

Two sets of analyses were conducted to analyse the impact of the Tape on participant food waste outcomes and the frequency of food-related behaviours. The first set focused on comparing the differences between the entire pre- and post-use survey samples. To account for the variations in normality in the food waste data, two types of tests were used to assess differences in food waste between pre- and post-use survey periods; the Welch's Analysis of Variance (Welch's ANOVA), a parametric test that does not assume equal variances, so it can be used for assessing unequal sample sizes (unlike a standard ANOVA), and the Mann–Whitney U test, a non-parametric test that assess differences between independent groups involving non-normal data. A third type of test, ordinal logistic regression (a parametric test that assess relationships between groups on an ordinal response variable), was used to estimate differences in food provisioning behaviours between these two periods.

The second set of analyses focused on those who had completed both pre- and post-use surveys (i.e., matched pairs). Wilcoxon signed-rank tests (a non-parametric test that does not assume normality in data) were used to assess differences in food waste between pre-

and post-use survey periods, and a generalised estimating equations (GEE) analysis was used to assess differences in food provisioning behaviours between these two periods (GEE can be used to assess non-normal repeated measures data). All statistical analyses were performed using SPSS version 28 (IBM SPSS Statistics).

3. Results

3.1. Study 1

Four main themes were identified when coding the video recordings and audio transcripts; (i) how the Tape was used, (ii) the food provisioning functions of the Tape, (iii) the behaviours it supported, and (iv) differences in the usefulness of the Tape based on household type/characteristics. These themes are further described below with illustrative quotes.

3.1.1. Tape Use

Participants used the tape in two different (and often complementary) ways (see Figure 2). The first was to demarcate space in their refrigerator or pantry to place any food to be used up. This was expected, as it was part of the instructions given to participants. Some used it in their pantry and refrigerator, while others only in their refrigerator. No participant used the Tape in their freezers.

The second way saw some participants tear off smaller sections of the Tape as labels on specific items they wanted to use up. This was not expected, as it was not communicated to the participants as an option and revealed a more flexible use of the Tape. Some participants even used specific "Eat me", "Pick me", "Cook me up" sections of the Tape to signify different intentions and uses for food (i.e., "Cook me up" to remind themselves of what needed to be included in the next meal, or "Eat me" as a visual prompt for other household members to eat that item when hungry).

(**a**) (**b**)

Figure 2. Example stills taken from participants' diaries showing how the Tape was used. (**a**) To mark individual food items to use up. (**b**) To mark out a shelf in the refrigerator (or pantry) to place items that needed to be used up.

3.1.2. Tape Functions

The Tape provided several different food provisioning functions for participants, who either used it for one main function or for several complementary functions. As was expected during the initial design of the Tape, a prominent function was to act as a visual prompt that reminded participants of foods that needed to be used up when they looked in the refrigerator or pantry—either through the Tape or the shelf it designated.

> *Marking containers with those items with the tape, makes it easy to identify . . . [yesterday] my wife spotted one of the containers with some leftover pork noodles in it, and thought, "I'll take that to work, rather than getting lunch at work".*

Participants often had similar items in their refrigerators or pantries which were bought at different times. The Tape was therefore used by some as a labelling device to help distinguish between older and newer versions of certain product.

> *This is really good for the eggs that we buy. We have eggs here that we bought more recently, but these are the older ones. And sometimes it can get confusing knowing which eggs we bought first. So these ones [labelled with the Tape] we'll use up first.*

An intention for the Tape was for it to support householders to make weekly meals with food that needed to be used up. Several participants mentioned how they deliberately used the Tape as a meal planning tool that helped to identify, when they looked in the refrigerator or pantry, the next meals that they would be preparing for their households.

> *And it's been really useful to just have food I need to cook in one area so that, at a glance maybe in the morning before going to work, I've been able to look at what I need to use up. And come up with an idea of what to cook. An improvement is I've cooked a couple of different dishes . . . new dishes that I haven't tried before, just because [I'm] trying to use up the food.*

A completely unexpected use of the Tape was as a communication tool between members of larger households as to what food in the refrigerator or pantry could be eaten if they were hungry between meals or what leftovers should be taken to work for lunch. Other household members could see, by looking for labelled items in the refrigerator or pantry, which food the main person responsible for cooking or shopping wanted them to eat as a snack or take to work for lunch.

> *It's been really helpful for my husband because he knows what leftovers he needs to eat. . . .. [and] in terms of communicating with the family anything that's on here they can generally eat. That's helpful, rather than having them having to ask me first.*

3.1.3. Behaviours Supported

Participants mentioned several specific waste reduction behaviours that the Tape supported. These included making meals that included food that needed to be used up; checking on existing food stocks before shopping and then making a shopping list; buying food types and amounts that they actually need when shopping; and avoiding takeaway/eating out options because they knew that there was food that needed to be used up.

> *It's been helpful to me for shopping lists . . . because when I look at what I've got and I think of recipes according to what I've got and then make the shopping list based on ingredients for what I want to make during the week. Rather than just think of all new ingredients without thinking first about what we need to use up.*

3.1.4. Differences in Usefulness Based on Household Characteristics

The Tape seemed to be more useful for larger (often family-based) households with large volumes of food use and/or disorganised individuals who do not usually plan out their food shopping, storage, and cooking.

> *. . .if you were already an organised person with good budgeting skills I don't think it would have a huge effect. But because I'm quite disorganised, I found it quite helpful.*
>
> *But the biggest success was with our daughter, who now can have a look at the food that's in the fridge and choose something [with the Tape on it]. She has a look, she can actually pull the container out and go, yeah, I want some of that.*

The Tape was less useful for smaller households (often singles or couples) who buy smaller amounts of food and/or for highly organised individuals who carefully plan their different food provisioning practices.

For myself. . . I think it's a bit hard because there's not an awful lot of food in the house, I guess, for one person. And you tend to know what you've bought because you're only buying a set amount of food and what's going to be coming out of date as it is.

I use everything I buy regularly and shop for what I'm going to consume. I don't prepare food and let it sit in the fridge. I shop for what I need, I prepare it, if I don't eat it that day. . . it's consumed the next day or the day after. So, this little simple system [the Tape] isn't effective for me.

3.2. Study 2

This section shows the results of analyses conducted to identify differences in food waste and behavioural frequency outcomes for the entire pre- and post-use survey samples (n = 361 and n = 144, respectively), and for those that completed both pre- and post-use surveys (n = 76 matched pairs). Two participants in the matched pairs did not complete all the questions, and as such were excluded from the analyses assessing differences between matched pairs (resulting in a final sample for matched pairs of n = 74).

3.2.1. Differences between Entire Pre- and Post-Use Samples

Preliminary analyses revealed that a small number of food waste categories contained non-normal data. However, all food provisioning behaviours contained normal data. To ensure a robust analysis, non-parametric tests (i.e., Mann–Whitney U test) were to complement the interpretation of the parametric tests (Welch's ANOVA) of differences in food waste between pre- and post-use samples.

Results from both Welch's ANOVA and Mann–Whitney's U test (see Table 3) indicate that the post-use sample had significantly less fresh vegetable waste and total food waste than the pre-use sample. A significant reduction in fresh fruit waste and bread from pre- to post-use sample was also found but only detected by Mann–Whitney U tests. Unexpectedly, the post-use sample experienced significant increases in fish waste. This effect could have been due to the small number of responses for this category of food waste influencing the accuracy of estimation in the analysis, or the use of non-random sampling and potentially unaccounted for individual differences that may have influenced the magnitude of this effect.

Table 3. Means, sample sizes, Welch statistic, and Mann–Whitney U result of differences in pre- and post-use samples of perceived food waste.

Measure	Pre Mean (g)	Pre Sample Size	Post Mean (g)	Post Sample Size	Welch	df1	df2	*p*	Mann–Whitney U	*p*
Fresh veg	**376.56**	**296**	**291.25**	**83**	**8.88**	**1**	**162.40**	**0.003**	**10,211.50**	**0.01**
Non-fresh veg	143.79	33	169	10	0.21	1	12.07	0.65	169	0.92
Fresh fruit	**395.19**	**219**	**331.09**	**48**	**3.59**	**1**	**68.81**	**0.06**	**4339**	**0.04**
Non-fresh fruit	80	14	93.33	3	0.03	1	2.28	0.88	15	0.51
Potatoes	302.40	64	332.80	18	0.13	1	20.64	0.72	516	0.47
Potato products	132.92	13	243.20	5	1.54	1	4.37	0.28	41.50	0.39
Pasta	207.13 [a]	55	229.65	17	0.21	1	25.84	0.65	500	0.64
Rice	210.45	77	213.33	18	0.003	1	21.55	0.96	627	0.49
Beans	224.89	18	92	3	[b]	[b]	[b]	[b]	10.50	0.10
Meat	242.58	96	192.39	23	1.44	1	41.04	0.24	970.50	0.35
Meat alts	171.09	16	278.57	7	3.34	1	14.24	0.09	81	0.10
Fish	**150**	**18**	**337.50** [a]	**6**	**13.28**	**1**	**14.42**	**0.003**	**89**	**0.01**
Sandwich	56.96	92	49.57	23	0.71	1	34.44	0.41	926.50	0.33
Bread	**289.36** [a]	**200**	**217.84** [a]	**63**	**2.48**	**1**	**107.18**	**0.12**	**5141.50**	**0.01**
Cereal	210.67	24	347.43	7	1.14	1	7.81	0.32	114	0.17
Yoghurt	357.27 [a]	88	307.83	23	0.79	1	57.37	0.38	1022	0.94
Cheese	115.69 [a]	52	155.43	14	1.04	1	16.84	0.32	421	0.27
Eggs	180	26	135	6	0.70	1	7	0.43	55.50	0.29
Stews	402.11	57	618.46	13	3.31	1	14.45	0.09	480	0.06
Condiment	249.50 [a]	42	284 [a]	14	0.13	1	22.38	0.72	327	0.51
Candy	61.67	18	58	2	0.04	1	6.59	0.85	44	0.97

Table 3. *Cont.*

Measure	Pre Mean (g)	Pre Sample Size	Post Mean (g)	Post Sample Size	Welch	df1	df2	*p*	Mann–Whitney U	*p*
Salty snacks	66.67	18	70	4	0.01	1	3.58	0.92	34	0.86
Nonalcohol	443.71 [a]	62	540	13	0.39	1	15.72	0.54	429	0.70
Alcohol	480.83 [a]	12	396.67	3	0.29	1	12.13	0.60	19	0.87
Total food waste	**1287.03** [a]	**361**	**784.97** [a]	**145**	**22.52**	**1**	**296.08**	**<0.001**	**16,815.50**	**<0.001**

Note: Significant effects are in bold. [a] Food waste category contains non-normal data. [b] Welch's ANOVA could not be performed for Beans category because at least one group had 0 variance.

The ordinal logistic regression results (see Table 4) found that the pre-use survey sample had approximately 48% lower odds of adopting the 'use it up meal' and approximately 85% lower odds of adopting the 'use it up shelf', relative to the post-use survey sample.

Table 4. Ordinal logistic regression results assessing differences in behavioural frequency between the entire pre- and post-use survey samples.

	Model Fitting Information		Goodness-of-Fit			Pseudo R-Square	Parameter Estimates		
	−2 Log Likelihood (Intercept, Final)	χ^2, df	Pearson	Deviance	df	McFadden	Coefficient	95% CI (Lower, Upper)	OR
Make a shopping list	35.83, 34.59	1.25, 1	0.17	0.17	3	0.001	−0.22	−0.62, 0.17	0.80
Check food at home before making a shopping list	34.24, 34.13	0.11, 1	1.61	1.89	3	0.00	−0.06	−0.43, 0.31	0.94
When shopping, only buy what is on shopping list	42.10, 41.91	0.20, 1	1.28	1.28	3	0.00	−0.08	−0.44, 0.28	0.92
Make a use it up meal	**49.76, 37.54**	**12.23 ***, 1**	**1.38**	**1.44**	**3**	**0.01**	**−0.65 *** **	**−1.02, −0.28**	**0.52**
Order takeaway	42.71, 39.98	2.73, 1	1.44	1.54	3	0.002	0.30	−0.06, 0.66	1.35
Have a use it up shelf in fridge/pantry	**104.44, 22.85**	**81.58 ***, 1**	**2.10**	**2.14**	**1**	**0.10**	**−1.88 *** **	**−2.29, −1.47**	**0.15**

Note: *** $p < 0.001$; χ^2 = chi-square; df = degrees of freedom; CI = confidence interval; OR = odds ratio. Note: Significant effects are in bold.

3.2.2. Differences between Matched Pairs

Results from the Wilcoxon signed-rank tests indicated significant reductions in food waste (see Table 5). Specifically, there was less total food waste, fresh vegetable waste, fresh fruit waste, and meat waste after the introduction of the Tape.

Table 5. Means, standard deviations, and Wilcoxon signed-rank results of food waste and food provision behaviour before and after introduction of the Tape.

Measure	Pre Mean (SD)	Post Mean (SD)	Wilcoxon Z	*p*	Effect Size
Fresh veg	**294.93 (288.06)**	**133.88 (181.95)**	**−4.98**	**<0.001**	**0.40**
Non-fresh veg	11.97 (57.86)	12.83 (60.99)	−0.05	0.96	0.00
Fresh fruit	**223.22 (253.88)**	**91.09 (174.58)**	**−3.59**	**0.001**	**0.29**
Non-fresh fruit	3.95 (16.34)	0.53 (3.22)	−1.90	0.06	0.15
Potatoes	32.34 (132.88)	45.47 (170.66)	−0.40	0.69	0.03
Potato products	8.42 (38.18)	2.53 (22.02)	−1.63	0.10	0.13
Pasta	26.11 (62.86)	18.53 (88.57)	−1.63	0.10	0.13
Rice	32.34 (72.33)	28.30 (119.53)	−1.08	0.28	0.09

Table 5. *Cont.*

Measure	Pre Mean (SD)	Post Mean (SD)	Wilcoxon Z	*p*	Effect Size
Beans	8.47 (45.51)	1.21 (10.55)	−1.60	0.11	0.13
Meat	**59.21 (138.46)**	**22.70 (77.96)**	**−2.18**	**0.03**	**0.18**
Meat alts	6.91 (46.12)	8.88 (48.94)	−0.28	0.78	0.02
Fish	2.47 (9.36)	6.91 (46.12)	−0.11	0.91	0.01
Sandwich	14.61 (33.76)	11.97 (30.02)	−0.63	0.53	0.05
Bread	112.74 (234.29)	100.18 (269.70)	−0.67	0.50	0.05
Cereal	5.05 (25.09)	16.84 (106.77)	−0.41	0.68	0.03
Yoghurt	82.11 (217.52)	44.21 (131.22)	−1.66	0.10	0.13
Cheese	8.42 (28.32)	8.42 (33.61)	−0.28	0.78	0.02
Eggs	9.47 (42.20)	5.13 (25.17)	−0.72	0.47	0.06
Stews	44.21 (139.73)	48.95 (176.56)	−0.42	0.68	0.03
Condiment	40.25 (162.33)	26.71 (85.62)	−0.32	0.75	0.03
Candy	2.11 (14.08)	0.26 (2.29)	−1.34	0.18	0.11
Salty snacks	4.61 (21.81)	3.68 (19.52)	−0.09	0.93	0.01
Nonalcohol	19.74 (65.28)	10.26 (47.38)	−0.86	0.39	0.07
Alcohol	34.41 (225.19)	9.41 (60.72)	−0.68	0.50	0.06
Total food waste	**1088.04 (931.35)**	**658.87 (759.61)**	**−4.87**	**<0.001**	**0.40**

Note: Significant effects in bold. SD = standard deviation.

The results of the generalised estimating equations are presented in Table 6. The findings showed no significant differences in the adoption of food provisioning behaviours between pre- and post-use survey periods.

Table 6. Generalised Estimating Equations analysis results for adoption of food provisioning behaviours by matched pairs.

Behaviour	Pre/Post Coefficient (SE)	Wald $\chi 2$ (df = 1, n = 74)	*p*
Make a shopping list	0.34 (0.35)	0.92	0.34
Check food at home before making a shopping list	0.03 (0.33)	0.01	0.94
When shopping, only buy what is on shopping list	0.48 (0.30)	2.52	0.11
Make a use-it up meal	0.29 (0.31)	0.88	0.35
Order takeaway	−0.37 (0.29)	1.65	0.20
Have a use-it up shelf in fridge/pantry	0.36 (0.36)	1.01	0.32

Note: SE = standard error; $\chi 2$ = chi-square; df = degrees of freedom; n = sample size; p = significance value.

4. Discussion

4.1. Summary of Principal Findings

The combined aim of the two studies presented in this paper was to explore how households used, and experienced, the OzHarvest Use it Up Tape ("the Tape"), to examine its impact on food waste and to identify any changes in household food provisioning behaviours that may have occurred.

The qualitative video diary study found that households used the Tape to mark out a designated space in their refrigerators or pantries to place food that needed to be used up, or stuck smaller sections of the Tape on specific items that needed to be used up (or

did both). The Tape served multiple functions for participating households; it functioned as a visual prompt, a labelling device, a planning tool, and a communication tool, and sometimes had multiple functions for the same household. Participants also indicated that the Tape helped them to engage in different food-related behaviours that reduced food waste, such as making meals with food that needed to be used up (the initial target behaviour) or sticking to their shopping list when shopping. The Tape seemed to be more useful and effective for large family homes and for individuals who were disorganised when shopping and/or cooking.

The quantitative study measured and compared self-reported food waste outcomes and behavioural frequencies before and after a two-week period of Tape use and found that there was a significant reduction in fresh vegetables, fresh fruit, and total food amounts wasted when comparing the entire pre- and post-use samples. The analysis of matched pairs (those who completed both pre- and post-use surveys) also found a significant reduction in fresh vegetables, fresh fruit and total food amounts wasted, as well as for meat. There also seemed to be a significant increase in the frequency across the entire pre- and post-use samples of participants who reported making a use-it-up meal before and after the two-week period, and an increase in designating a use-it-up shelf in fridges/pantries. However, increased engagement in these behaviours was not shown in the matched pairs analyses.

4.2. Implications for Food Waste Reduction Policies and Programs

While visual prompt-type nudges have been previously explored with regard to their influence on food waste recycling behaviours [28], to the best of our knowledge this is one of the few studies that looks at their influence on reducing or preventing food waste [13,15]. In their recent study, [11] included reminder stickers and other 'salience tools' in the suite of food waste reduction tools they provided to participants. However, they mainly measured the collective impact of all the tools, rather than looking at their individual impact. Ref. [10] did look more specifically at the influence of different salience tools—a basket for collecting food items that need to be used up, a whiteboard for noting these items, and clips to attach to items—and found that they did not have an added impact on food waste levels.

Our study supports arguments by [15] on the potential of behaviourally orientated nudges such as visual prompts to reduce food waste in households. The most wasted food items in Australian households are fresh vegetables, fresh fruit, and bread/baked goods [29], and the use of the Tape seemed to lead to a reduction in fruit and vegetables wastage in participating households (but no significant reduction for bread/baked goods). This shows that not only did the Tape support an overall reduction in food waste for participants, but was particularly effective in tackling some of the more commonly wasted items in the Australian context. We speculate the wastage of bread and other baked goods may not have been reduced because the Tape may not have been used in the areas in the kitchen where these items are commonly stored (i.e., in bread storage bins and/or freezers).

While the results were not consistent between the analysis of the entire pre- and post-use samples and matched pairs, the quantitative study did suggest that the Tape supported an increase in the target behaviour for the campaign, namely making a regular meal that combines food that needs to be used up. This leads us to conclude that it was the increased frequency of this behaviour which may have led to the food waste reduction outcomes that were measured. This finding is important not just because it highlights the effectiveness of the Tape as a behaviourally orientated nudge, but also because it supports that decision to include this target behaviour in the overall Use It Up campaign as an effective way to reduce food waste in Australia [16].

In their study of the effectiveness of stickers attached to weekly home food delivery plastic bags to prompt consumers to return them for re-use, [17] described these types of reminders as 'action-close' or 'point-of-decision' prompts. They argued that these types of nudges are particularly effective as they "catch decision makers attention in the situation and at the time of the desired behaviour change" (p. 2). Their study showed that the reminder's proximity to the action was critical and that "reminders issued at the time

and in the situation of the taking action can bridge limited attention more effectively than conventual, action-distant reminders" (p. 2). For policy and program managers seeking to reduce food waste, this positions the effectiveness of behaviourally orientated nudges like the Tape against more conventional campaigns providing information and raising awareness [11,13]. While an increased consumer awareness of global and personal food waste implications, and what could be done to address these, is important, individuals also need to be prompted of the necessary behaviours at the time and place when they are most relevant, namely when they are standing at their refrigerator or pantry looking for something to eat or cook.

Of final relevance to policy and program managers is the varying effectiveness of the Tape based on the characteristics of the household. The qualitative study showed that family-based households with young children, and those households in which the primary person responsible for shopping or cooking (the dietary gatekeeper) was particularly disorganised, responded the best to the Tape and found it effective. As with any nudge-based (or indeed any other type of) behaviour change intervention, a targeted implementation of the Tape that engages with particular household-types is needed, as is the creation of a broader range of complementary food waste reduction tools that might be relevant for other households [11].

4.3. Limitations and Future Research

While the size of the sample of Study 1 was adequate for a qualitative exploration of the experience of participants in using the Tape, we do note that higher income households were not well-represented. A slightly expanded sample that also investigated how the Tape was used in these types of households would have allowed for more comprehensive conclusions to be reached in Study 1.

The variations noted in the outcomes for the entire pre- and post-use samples and those for the matched pairs might have been due to several factors, namely the quasi-experimental nature of the intervention and the lack of a true control condition. Not only does this make it difficult to establish the Tape as the causal mechanism behind the observed food waste reduction, but the nature of the intervention also means that participants self-nominated their participation, and this might introduce a type of selection bias to the study. Namely, participants were potentially already motivated to reduce food waste from the onset, particularly those that were organised and engaged enough to complete both the pre- and post-use survey. These matched pair participants, in particular, may have been already engaging in certain food provisioning behaviours that reduce food waste, with little opportunity to do them more in the two-week period allotted to their participation.

Related to measurement issues, [26] acknowledge that participants using their food waste measurement survey typically underestimate the amount of food that they waste, a problem which has been highlighted for other survey-based food waste self-reporting tools [30]. However, they still point to the value this tool provides in comparing food waste amounts between households or across time for the same households. The results presented in this study should therefore not be seen as accurate measures of Australian food waste, but rather as a way to test the effectiveness of the Tape by comparing between participating households.

The relatively small sample sizes within the quantitative study may have influenced our ability to detect the effects of the Tape. A follow-up study with a larger sample size might provide more robust findings with regard to food waste and behavioural outcomes, and the sample of the qualitative study could also be expanded to be more nationally representative for Australia. Follow-up quantitative studies with larger sample sizes might also need to consider Odds Ratios (ORs) and the underlying data when interpreting the results of an ordinal logistic regression [31]. ORs can be influenced by other factors in the data, such as the presence of confounding variables [32] or the distribution of the predictor and outcome variables [31]. Given the low sample size, covariates were not included in the analysis and, as such, it is unknown whether the results are influenced by any other factors.

Future research on nudges such as the Tape might include a control condition and repeated measures of outcomes over a longer period to enable more robust conclusions about the long-term use of this type of tool and its impacts. Everitt et al. [7] recently published the outcomes of a broader food waste reduction campaign in Canada that was based on a randomised control trial and repeated measurements from 2017–2020. Quantitative design issues, such as those listed above, highlight the value of including a qualitative element to this research, which has allowed researchers to understand what is going on inside of participants' homes and how they have interacted with the Tape. Future research would benefit from being able to implement a more strictly controlled delivery and the adoption of 'action-close' nudges, such as the Tape, with the inclusion of a true control condition to allow for more stringent comparisons. Additionally, wherever possible, including qualitative measures is recommended to complement the accuracy of self-reported measures and behaviours.

5. Conclusions

When engaging consumers to play their part in tackling the global food waste challenge, it is becoming increasing clear that simply providing information about the challenge and what they need to do is not enough to lead to a meaningful behaviour change. Action-close behaviourally orientated nudges and prompts, such as the OzHarvest Use it Up Tape, play an important role in supporting consumers to turn their intentions to reduce food waste into action by engaging them when they are paying attention to food, i.e., when opening their refrigerator or pantry in order to prepare a meal. There is an opportunity to create multi-faceted interventions that map daily consumer behaviours related to food waste and utilise a mix of both behaviourally and cognitively orientated nudges, to provide the appropriate support for different behaviours and ensure ongoing food waste reduction outcomes.

Author Contributions: Conceptualisation, M.B.; methodology, M.B. and N.L.; formal analysis, M.B. and N.L.; investigation, M.B.; resources, M.B.; data curation, M.B. and N.L.; writing—original draft preparation, M.B. and N.L.; writing—review and editing, M.B. and N.L.; project administration, M.B.; funding acquisition, M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research project was commissioned by OzHarvest and partially supported by funding from the Australian Government's Environmental Restoration Fund and from the Western Australian Department of Water and Environmental Regulation.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Committee of Monash University (project ID # 28967 and # 32508).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets presented in this article are not readily available, as they belong to OzHarvest. As the research commissioners, requests to access the datasets should be directed to OzHarvest.

Acknowledgments: We are very grateful to Ronni Kahn AO, Ruby Wake, Monique Llewellyn, Annika Stott and Fiona Nearn at OzHarvest for their collaboration in this research, guidance, and support. We would also like to thank all research participants for their involvement.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Candeal, T.; Brüggemann, N.; Bruns, H.; Casonato, C.; Diercxsens, C.; García-Herrero, L.; Gil, J.M.; Haglund, Y.; Kaptan, G.; Kasza, G.; et al. *Tools, Best Practices, and Recommendations to Reduce Consumer Food Waste—A Compendium*; Publications Office of the European Union: Luxembourg, 2023.
2. FAO. *The State of Food and Agriculture 2019. Moving forward on Food Loss and Waste Reduction*; Food & Agriculture Organization of the United Nations: Rome, Italy, 2019.

3. UNEP. *Food Waste Index Report 2021*; United Nations Environmental Program: Nairobi, Kenya, 2021.
4. Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S.; Garnett, T.; Tilman, D.; DeClerck, F.; Wood, A.; et al. Food in the Anthropocene: The EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet* **2019**, *393*, 447–492. [CrossRef] [PubMed]
5. Transforming Our World: The 2030 Agenda for Sustainable Development. Available online: https://sustainabledevelopment.un.org/post2015/transformingourworld/publication (accessed on 10 May 2024).
6. Reynolds, C.; Goucher, L.; Quested, T.; Bromley, S.; Gillick, S.; Wells, V.K.; Evans, D.; Koh, L.; Carlsson Kanyama, A.; Katzeff, C.; et al. Consumption-stage food waste reduction interventions—What works and how to design better interventions. *Food Policy* **2019**, *83*, 7–27. [CrossRef]
7. Everitt, H.; van der Werf, P.; Seabrook, J.A.; Gilliland, J.A. The proof is in the pudding: Using a randomized controlled trial to evaluate the long-term effectiveness of a household food waste reduction intervention during the COVID-19 pandemic. *Circ. Econ. Sustain.* **2023**, *3*, 881–898. [CrossRef] [PubMed]
8. Shu, Y.; Booker, A.; Karetny, J.; O'Keefe, K.; Rees, K.; Schroder, L.; Roe, B.E. Evaluation of a community-based food waste campaign using a national control group. *Waste Manag.* **2023**, *160*, 101–111. [CrossRef] [PubMed]
9. Soma, T.; Li, B.; Maclaren, V. An evaluation of a consumer food waste awareness campaign using the motivation opportunity ability framework. *Resour. Cons. Recycl.* **2021**, *168*, 105313. [CrossRef]
10. Cooper, A.; Lion, R.; Rodriguez-Sierra, O.E.; Jeffrey, P.; Thomson, D.; Peters, K.; Christopher, L.; Zhu, M.J.H.; Wistrand, L.; van der Werf, P.; et al. Use-up day and flexible recipes: Reducing household food waste by helping families prepare food they already have. *Resour. Cons. Recycl.* **2023**, *194*, 106986. [CrossRef]
11. van Herpen, E.; Wijnen, T.; Quested, T.; Reynolds, C.; Sharda, N. Convenient tools and social norms: Measuring the effectiveness of an intervention to reduce household food waste. *J. Clean Prod.* **2023**, *429*, 139604. [CrossRef]
12. Nisa, C.F.; Bélanger, J.J.; Schumpe, B.M. Assessing the effectiveness of food waste messaging. *Environ. Sci. Policy* **2022**, *132*, 224–236. [CrossRef]
13. Simões, J.; Carvalho, A.; Gaspar de Matos, M. How to influence consumer food waste behavior with interventions? A systematic literature review. *J. Clean Prod.* **2022**, *373*, 133866. [CrossRef]
14. Tian, X.; Xia, Z.; Xie, J.; Zhang, C.; Liu, Y.; Xu, M. A meta-analytical review of intervention experiments to reduce food waste. *Environ. Res. Lett.* **2022**, *17*, 064041. [CrossRef]
15. Zhang, J.; Huang, Y.; Zhu, J.; Zhao, L. A meta-analysis on the effectiveness of food-waste reducing nudges. *Food Policy* **2023**, *120*, 102480. [CrossRef]
16. Boulet, M.; Stott, A.; Kneebone, S. Which behaviours matter? Prioritising food waste reduction behaviours for targeted policy and program approaches. *J. Environ. Manag.* **2023**, *345*, 118668. [CrossRef]
17. Essl, A.; Steffen, A.; Staehle, M. Choose to reuse! The effect of action-close reminders on pro-environmental behavior. *J. Environ. Econ. Manag.* **2021**, *110*, 102539. [CrossRef]
18. Sussman, R.; Gifford, R. Please turn off the lights: The effectiveness of visual prompts. *Appl. Ergon.* **2012**, *43*, 596–603. [CrossRef]
19. Kahneman, D. *Thinking, Fast and Slow*; Farrar, Straus and Giroux: New York, NY, USA, 2011.
20. Thaler, R.H.; Sunstein, C.R. *Nudge: Improving Decisions about Health, Wealth and Happiness*; Penguin Books: London, UK, 2002.
21. Conner, M.; Norman, P. Understanding the intention-behaviour gap: The role of intention strength. *Front. Psychol.* **2022**, *130*, 923464. [CrossRef] [PubMed]
22. Boulet, M.; Hoek, A.C.; Raven, R. The gaze of the gatekeeper: Unpacking the multi-level influences and interactions of household food waste through a video elicitation study. *Resour. Cons. Recycl.* **2021**, *171*, 105625. [CrossRef]
23. Dodds, S.; Bulmer, S.; Murphy, A. Incorporating visual methods in longitudinal transformative service research. *J. Serv. Theory Pract.* **2018**, *28*, 434–457. [CrossRef]
24. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
25. Cho, J.Y.; Lee, E.-H. Reducing confusion about grounded theory and qualitative content analysis: Similarities and differences. *Qual. Rep.* **2014**, *19*, 1–20. [CrossRef]
26. van Herpen, E.; van Geffen, L.; Nijenhuis-de Vries, M.; Holthuysen, N.; van der Lans, I.; Quested, T. A validated survey to measure household food waste. *MethodsX* **2019**, *6*, 2767–2775. [CrossRef]
27. Shu, Y.; Roe, B.E.; Bender, K. Adapting, refining and expanding a validated questionnaire to measure food waste in U.S. households. *MethodsX* **2021**, *8*, 101377. [CrossRef] [PubMed]
28. Shearer, L.; Gatersleben, B.; Morse, S.; Smyth, M.; Hunt, S. A problem unstuck? Evaluating the effectiveness of sticker prompts for encouraging household food waste recycling behaviour. *Waste Manag.* **2017**, *60*, 164–172. [CrossRef] [PubMed]
29. Karunasena, G.G.; Pearson, D. *Fight Food Waste Cooperative Research Centre Australian Household Food Waste: A Summary of Behaviours, Attitudes, Perceived and Actual Food Waste*; Fight Food Waste Cooperative Research Centre: Urrbrae, Australia, 2021.
30. van Herpen, E.; van der Lans, I.; Holthuysen, N.; Nijenhuis-de Vries, M.; Quested, T. Comparing wasted apples and oranges: An assessment of methods to measure household food waste. *Waste Manag.* **2019**, *88*, 71–84. [CrossRef] [PubMed]

31. Agresti, A. *Categorical Data Analysis*, 3rd ed.; John Wiley & Sons: Hoboken, NJ, USA, 2013.
32. Rothman, K.J.; Greenland, S.; Lash, T.L. *Modern Epidemiology*, 3rd ed.; Lippincott Williams & Wilkins: Amsterdam, The Netherlands, 2008.