Resources, Conservation & Recycling 144 (2019) 256–266

Contents lists available at ScienceDirect

Resources, Conservation & Recycling

journal homepage: www.elsevier.com/locate/resconrec

Full length article

Waste minimization by households – A unique informational strategy in the Netherlands

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ARTICLE INFO

Keywords:
Household waste minimization
Informational strategy
Norm activation model
Field study

ABSTRACT

Households can minimize residual waste and increase the volume of materials recycled by improving waste separation and changing purchasing behaviour. Informational strategies may provide people information on reasons to minimize waste and information on how to minimize waste. However, a meta-analysis found that the effect of informational strategies on waste minimization is small to medium. While some studies find effects, others do not. To improve the effectiveness of informational strategies to promote waste minimization, it is important to better understand the underlying processes. We proposed and tested if an intervention, consisting of an innovative informational strategy, strengthens the variables from the norm activation model, i.e. increased awareness of consequences, outcome efficacy and personal norms. We conducted a field study in collaboration with a waste collection company. The current study not only tested if the intervention increased the separation of waste, but also whether households changed their purchase behaviour and if they reduced the volume of residual waste. We included self-reported as well as actual behaviour and tested long term effects after the programme ended. Our findings show that the informational strategy effectively reduced households' waste. Furthermore, the intervention changed waste behaviour partly via the variables from the norm activation model. Particularly, awareness of consequences and outcome efficacy explained the influence of the intervention on waste minimization. Our findings suggest that informational strategies may be effective in minimizing household waste when awareness of consequences and outcomes efficacy are increased by the information.

1. Introduction

1.1. Waste minimization

To reduce environmental problems the current paper studies a strategy to reduce waste. Municipal waste (MW) consists of valuable resources that are discarded during waste disposal. Nonetheless, the average citizen of the European Union (EU) disposes 480 kg of MW per year (Eurostat, 2018). Municipal waste is defined as waste collected by municipal authorities. It mainly consists of waste generated by households, but also includes waste from shops, offices and public institutions. More than half of the MW in the EU is either landfilled or incinerated (Eurostat, 2018). Especially when MW is not recycled, it can result in large environmental impacts. If MW is not recycled, new material resources need to be exploited. Exploitation of material resources is unsustainable in the long term (Henckens et al., 2014), considerable environmental impacts are associated with new material extraction and the production of new goods (Corsten et al., 2013).

Households can play a key role in the reduction of environmental impacts from MW. Households can mainly reduce environmental impacts through: 1) The reduction of the total amount of MW and 2) The improved sorting of MW into separately collected waste streams as amongst others: plastic, organic, glass, and paper and cardboard waste (see e.g. Corsten et al., 2013). Changes in household purchase behaviour can contribute to the reduction and improved sorting of MW as well. Households may purchase reusable products or decrease their consumption altogether. In this paper we define the sorting and purchasing behaviours in order to reduce environmental impacts as 'waste minimization'. A crucial question for waste collection companies and governments is how waste minimization can be promoted, to achieve deep reductions in environmental impact from (residual) waste generation by households.

The present paper tests the influence of an innovative informational strategy aiming to promote household's waste minimization. Importantly, to better understand why an informational strategy may be effective the processes underlying the effectiveness of the strategy

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https://doi.org/10.1016/j.resconrec.2019.01.032
Received 29 August 2018; Received in revised form 27 November 2018; Accepted 21 January 2019

will be tested. More specifically, the current paper tests if the informational strategy influences the variables from the norm activation model. It will be evaluated if the strategy influences waste minimization, including self-reported and actual produced (residual) waste. Furthermore, the effect of the strategies on the short as well as on the long term will be tested.

In the next section we present a literature overview on the influence of informational strategies on waste minimization. Next, the norm activation model will be explained and how informational strategies may influence the variables from the norm activation model and thereby waste minimization. In the method section the research design, including a description of the strategy used and the used measures of waste minimization will be explained. In the results section the outcomes of the study are presented. Finally, the theoretical and practical implications of the study will be discussed.

2. Background

2.1. Informational intervention strategy

One way to promote waste minimization is by using informational intervention strategies. Informational strategies aim to change people's knowledge, perceptions, motivations or norms and thereby promote sustainable waste behaviour (Messick and Brewer, 1983; Steg and Vlek, 2009). For example, informational strategies may provide people with knowledge on how and where to recycle, aiming to increase recycling behaviour. A meta-analysis on the effectiveness of intervention strategies to promote recycling behaviour found that informational strategies can promote recycling behaviour (Varotto and Spagnolli, 2017). Specifically, it was found that providing people with information on how to recycle and information on the importance of recycling has a small to medium effect on recycling behaviour. Sometimes informational strategies influence waste minimization, other times they do not.

For example, providing households with a flyer or leaflet containing information on why one should recycle and how to recycle, increased recycling rates (Bowman et al., 1998; Hopper and Nielsen, 1991). Students living in residence halls were found to increase the amount of recycled paper and glass after receiving information on why and how to recycle (Iyer and Kashyap, 2007). Several studies also found that visiting households (door stepping) and providing them with information can minimize waste. Such information increased the amount of recycled waste (Lord, 1994; Read, 1999), the amount of sorted food waste (Dai et al., 2015), the total amount of recycled materials and the number of households participating in recycling (Grodzińska-Jurczak et al., 2006).

However, other studies did not find effects of informational strategies on waste minimization. Providing participants with information on how to recycle and why it is important to do so did not increase the frequency with which people recycled (Schultz, 1999), the amount of separately collected food waste (Bernstad, 2014; Bernstad et al., 2013), the amount of recycling or the contamination levels of recycled waste (Timlett and Williams, 2008), the frequency with which students sort their waste (Dupré, 2014), self-reported recycling in student residence halls (Goldenhar and Connell, 1991) nor did it reduce the amount of residual waste (Bernstad et al., 2013). Finally, providing households with a leaflet or text messages emphasizing the environmental benefits or emphasizing the local social benefits of recycling also did not increase the amount of recycled waste (Chong et al., 2013).

To better understand why informational strategies may effectively promote waste minimization or why not, it is important to understand the underlying processes or mechanisms. When the underlying processes are clear, future strategies can target these underlying factors, thereby increasing the effectiveness of the intervention strategy. However, few studies have addressed the underlying processes in interventions aiming to promote waste minimization (Varotto and Spagnolli, 2017).

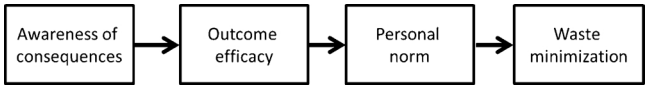

Fig. 1. The norm activation model.

2.2. The norm activation model

The current paper will test if informational intervention strategies promote waste minimization because variables from the norm activation model are increased (see Fig. 1). According to the norm activation model (Schwartz, 1977) behaviour is influenced by one's personal norm. Personal norms are defined as the extent to which people feel morally obliged to engage in the behaviour, in this case to minimize their waste. When people feel morally obliged to minimize waste they are more likely to actually engage in these behaviours. Personal norms are influenced by outcome efficacy, i.e. the extent to which people think their behaviour can contribute to reducing problems. Finally, outcome efficacy is stronger when awareness of consequences is strong. Awareness of consequences can be defined as the extent to which people are aware of the problems caused by their behaviour; in this case the extent to which they are aware that waste causes environmental problems. An informational strategy informing people how to minimize their waste and reasons on why it is important to do so may increase the variables from the norm activation model. More specifically, providing people with information on why it is important to minimize waste, e.g. by providing information on the environmental problems caused by waste, may increase the extent to which people are aware of problems caused by waste (i.e. awareness of consequences). Providing people with information on how they can recycle is likely to increase the extent to which people think their behaviour can contribute to solving the problems (i.e. outcome efficacy).

Correlational studies suggest that the variables from the norm activation model indeed influence waste minimization. People are more likely to recycle when they are aware of problems caused by recycling, think they can contribute to reducing the problem, and feel morally obliged to recycle (Guagnano et al., 1995; Park and Ha, 2014; Vining and Ebreo, 1992). Furthermore, when people are aware of problems caused by locally burning waste and think their behaviour reduces these problems they are less likely to burn yard waste (Liere and Dunlap, 1978). Importantly, research suggests that providing people with information on social or sustainable problems caused by certain behaviours can indeed influence behaviour by strengthening awareness of consequences, which in turn increases outcome efficacy, and personal norms (Steg and De Groot, 2010). However, the latter study focused on prosocial and general sustainable behaviour, raising the question if informational strategies do influence waste minimization via the variables from the norm activation model as well?

A few studies tested the influence of informational strategies to promote waste minimization on the variables from the norm activation model. A study by Dai et al. (2015) found that visiting households and providing them with information on the environmental problems caused by not recycling food waste increased the recycling of food waste. The informational strategy did not significantly increase awareness of problems caused by not separating food waste. However, in this study only one item was used to measure awareness of consequences. Furthermore, this item was measured on a dichotomous scale, making it more difficult to find effects. Also, the other variables from the norm activation model were not measured. The UK WRAP programme launched the 'Love food, hate waste' campaign that aimed to make people aware of food waste. An evaluation of the program showed that awareness of the problem increased from before to after the intervention. However, as the study did not include a control group it is not possible to attribute the changes in awareness to the WRAP programme (Quested et al., 2011). A study in which block leaders visited households and provided them with information on which waste

streams they could recycle did increase recycling, but did not find effects on the variables from the norm activation model (Hopper and Nielsen, 1991). More specifically, awareness of consequences and the personal norm to recycle were not influenced by the provided information. However, providing households with information on how to recycle waste may influence the extent to which people think their behaviour can help solve the problem. That is, it may particularly influence outcome efficacy yet this was not measured in the study. In the current study, we aim to test if an informational strategy to minimize waste, influences the variables from the norm activation model. We will not only test if the informational strategy increases awareness of consequences, but we will also test the influence of the informational strategy on outcome efficacy and personal norms, and how this impacts waste minimization.

2.3. Aims and hypotheses

The current paper aims to test the influence of an informational strategy on waste minimization and the underlying process. Most studies testing if intervention strategies promote waste minimization do so by testing if the strategy increases the amount of recycled materials or the number of participants in a recycling scheme (Varotto and Spagnolli, 2017). However, as explained above, to reduce environmental problems, households should not only sort their waste but also reduce overall generation of waste. Therefore, in the current study several waste minimization outcomes are included. In addition to testing if households separate their waste better and change their purchase behaviour, we test if the total volume of residual waste is reduced following the informational strategy. Furthermore, self-reported measures of waste behaviour may not always be strongly related to actual behaviour as people may answer in a socially desirable way (Corral-Verdugo, 1997). Therefore, self-reported residual waste as well as actual residual waste is measured. Finally, effects of interventions aiming to promote waste minimization may disappear after these have ended (Porter et al., 1995). Therefore, the influence of the strategy on waste minimization in the short term as well as in the long term after the intervention has ended is tested. We expect that an intervention consisting of an informational strategy influences the waste minimization outcomes in the short and long term. We hypothesize that the intervention influences the waste minimization outcomes via awareness of consequences, outcome efficacy and personal norms.

3. Method

This study was part of the intervention strategy "100-100-100"[1], designed by the publically owned Dutch waste collection company ROVA. The intervention started on January 1st 2015, with the aim to get 100 households to live 100% waste free for 100 days. In this case 100% waste free means no residual waste.

3.1. Participants and procedure

Inhabitants of the regions served by ROVA could voluntarily sign up for the intervention via a website which was advertised by ROVA in local media. ROVA serves households in a relatively rural area of the Netherlands, including two cities with less than 150.000 inhabitants. Before the start of the intervention, ROVA organized an information evening where the programme was explained. About 80% of all participating households attended this information evening. A control group was established by contacting people via email who had before indicated that they would be willing to participate in studies by ROVA[2]. We therefore had a quasi-experimental design.

A questionnaire was sent to each participating household and all households in the control group four weeks before the start of the intervention, in order to establish a baseline (t1, see Fig. 2). Furthermore, questionnaires were sent to all households seven weeks after the start of the intervention (t2), directly after the intervention ended (t3), as well as six months after the intervention ended (t4). Each time, the questionnaire was online for three weeks. After two weeks the households, who had not yet responded, received an email reminder. In total there were 409 unique participants of which 126 participants filled out all four questionnaires.

We measured the demographic variables in the first questionnaire (see Table 1). Compared to the average household in this part of the Netherlands the sample is older and has a higher level of education. Income is comparable to the average in this part of the Netherlands, people living in single households are underrepresented (Databank Overijssel, 2015; Cijfers over Zwolle, 2015). Furthermore, more people have a garden compared to the average in the Netherlands (CBS, 2015).

3.2. The intervention

The informational intervention strategy consisted of a range of interventions (see Table 2). During the information evening (see above), participating households were asked to sign a form indicating that they would participate in the study and fill out the questionnaires as part of the evaluation. About 80% of all participating households attended this information evening and signed the form. Via an online environment, where participating households could login, they received tips on how to separate, recycle, and reduce their waste, and they had the opportunity to share tips with other participants as well. ROVA provided five tips. Furthermore, households received fourteen weekly assignments in the online environment aimed to provide them with insight into their waste behaviour. In total participants received 14 assignments. In the online environment, participating households could also report the amount of residual waste they produced per week. The reported values could be compared to the average reported amount of residual waste by all households in the area and the reported values of other households.

The intervention started on January 1st, 2015 and lasted for 100 days, until April 10th, 2015. Between December 2014 and June 2015, there were 12,411 visits to the projects' website. On average, people spent three minutes and 39 s on the website per visit. Of the total number of households responding to one of the questionnaires 203 received the informational strategy, and 206 households were part of the control group. The control group did not receive any of the information from the informational intervention strategy.

3.3. Monitoring results

We monitored self-reported behaviour via the online questionnaire.

Separating waste. Separating waste was measured by asking participants to what extent they separate specific waste streams, i.e. glass, paper, plastics, organic waste, textile, cooking oil, electronics and chemical waste. Participants could answer on a scale from 1 (nothing at all) to 7 (everything) or indicate that it was not applicable to them. We calculated the average of all streams. The Cronbach's alpha in the different questionnaires were respectively 0.77, 0.94, 0.92, and 0.84. The means and standard deviations are reported in Table 3.

Residual waste. Participants were asked to indicate how many bags

[1] See www.100-100-100.nl

[2] The program also included a second intervention group. This group consisted of 50 participants who received the same information as the first intervention group. In addition, households received a bin to help them separate waste. However, for this intervention group specific people were selected. For example, aldermen were invited into this group to increase attention for the project in the local media. Therefore, this group cannot be compared to the informational strategy group.

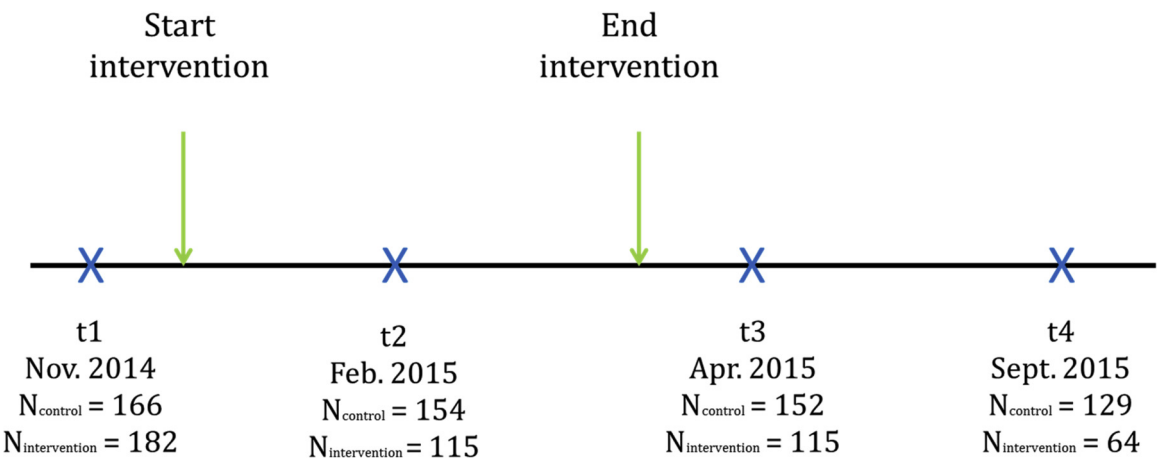

Fig. 2. Overview of the four measurements via the questionnaire and the number of participants who filled out each questionnaire.

Table 1
Overview of the socio-demographic characteristics of the sample.

Parameter	Options	Value
Gender	Male	154 (44%)
	Female	194 (56%)
Age		20 - 82 M = 50.1 (SD = 12.60)
Household size		1 – 11 M = 2.9 (SD = 1.53)
Living situation	Alone	45 (13%)
	With partner	133 (38%)
	With partner and children	155 (45%)
	Without partner, with children	12 (3%)
	Other	3 (0%)
House	Apartment	24 (7%)
	Low-rise with garden	316 (91%)
	Low-rise without garden	7 (2%)
Net monthly household income	< 1800 euros	64 (18%)
	1800 – 3150 euros	122 (35%)
	> 3150 euros	108 (31%)
	Prefer not to say	54 (16%)
Education level	Primary or high school	54 (16%)
	Vocational education	99 (29%)
	Bachelor degree	150 (43%)
	Master degree	44 (13%)

Table 2
Overview of the channels and methods used in the informational strategy.

Channel	Method
Information evening	Sign contract to participate in the project and its evaluation
Online environment	Waste reduction tips provided by the waste organization *1. Drinking and beverage cartons should be included in plastic waste;* *2. Diapers should be included in residual waste;* *3. Crisps and pasta bags are made from two materials therefore they cannot be recycled, try to look for alternatives made from one material;* *4. Cigarette butts cannot be recycled, try to quit smoking during the intervention;* *5. Cans should be included in the plastic waste* Share tips with other households *See rova.100-100-100.nl* Weekly assignment to increase awareness of waste: 1 *Count how many packages do you open on one day. (155 responses)* 2 *Make a picture of the waste you produced in preparing one warm meal. (177 photo's)* 3 *Who has the best tip to reduce waste? (76 tips received)* 4 *Which shopkeeper helps to prevent waste? (19 nominations)* 5 *Make a list of food products you have in the cupboard. (1 household won a dinner made from these products)* 6 *What is your best leftover recipe?* 7 *How many used mobile phones can you collect? (69 in total)* 8 *Which product do you give a second live?* 9 *Which appliance can you share with others?* 10 *Where in your house do you produce waste?* 11 *Which package did you notice most during the intervention?* 12 *How waste free is your pet?* 13 *Where do you find waste outside?* 14 *Count how many packages you open on one day.* Compare own waste to others

(50 litres), small containers (140 litres) or large containers (240 litres) of residual waste their household produced per month. We calculated the total number of litres per month, see Table 3.

Waste prevention. We used six items to measure to what extent participants try to prevent their household waste. Participants could answer on a scale from 1 (never) to 7 (always) to what extent they engage in the following behaviours: I bring my own bag when I go shopping for groceries; I avoid products with a lot of packaging when shopping; I prevent paper use (e.g., by printing double sided); I reduce my waste; I throw away food when the expiry date has passed *recoded*; I throw away food when I bought or prepared too much *recoded*. The last two items were recoded to ensure higher scores reflect more waste prevention. We calculated Cronbach's alpha for the scale for the four measurements to be 0.72, 0.71, 0.69, and 0.73.

Actual residual waste. In addition to the self-reported measure of recycling and waste reduction in the questionnaire, the actual waste of households was measured. Before the start of the intervention (t1) and at the end of the intervention (t3) the residual waste was collected over a period of two weeks. Households from the control group were not examined. The waste was measured on a group level. Fifty of the households in the informational strategy group were randomly selected to be included in the waste analysis. In total, the waste of 40 households from the informational strategy group was collected individually in both periods of two weeks.

The residual waste was analysed in three sorting tests: a quantitative sorting test, a qualitative sorting test, and weighting. The quantitative and qualitative sorting tests were done by a company specialized in waste sorting and analysis (EURECO). The weighting was performed by ROVA during the collection of the waste. The waste was sorted into product categories. Next, the weight of each category was measured. During the qualitative sorting test, the waste was hand-picked and separated in different categories. All the correctly sorted waste was then combined and weighted. All the incorrectly sorted waste was also

Table 3
Means and standard deviations for residual waste, overall recycling behaviour and waste prevention.

	t1	t2	t3	t4
Separating waste (overall)	5.48 (1.26)	6.30 (1.17)	6.33 (1.07)	6.47 (.76)
Residual waste (litres/ household)	143 (151)	141 (181)	139 (178)	137 (157)
Waste prevention	4.92 (1.04)	5.08 (.99)	5.20 (.96)	5.15 (1.04)

Table 4
Means and standard deviations for Awareness of consequences, outcome efficacy, personal norm, and perceived ease to recycle.

	t1	t2	t3
Awareness of consequences	4.78 (1.33)	4.87 (1.43)	4.93 (1.41)
Outcome efficacy	5.61 (1.08)	5.76 (1.26)	5.81 (1.20)
Personal norm	5.86 (1.17)	5.96 (1.19)	5.96 (1.22)

combined and weighted. Incorrectly sorted waste includes all waste should have been put into a different (separately collected) waste stream, e.g. organic waste that was included in residual waste. To compare the results, the amounts were recalculated to kilograms per inhabitant per year by dividing the kilograms by 14 (days), multiplying it by 365 and dividing it by the number of people in the household.

Awareness of consequences. Awareness of consequences was measured with two items (i.e. I worry about the depletion of raw materials caused by not separating waste; I think not separating waste causes environmental problems such as the depletion of raw materials). We measured awareness of consequences at t1, t2 and t3. Cronbach's alpha was sufficient: 0.80, 0.83, and 0.82. The means and standard deviations are reported in Table 4.

Outcome efficacy. We measured outcome efficacy with three items (i.e. I think I can contribute to reducing environmental problems by separating my waste; I think I can contribute to the reduction of the depletion of raw materials by separating my waste; environmental quality will improve when I separate my waste). Outcome efficacy was measured at t1, t2 and t3. Cronbach's alpha was: 0.77, 0.86, and 0.90.

Personal norm. We measured personal norm with three items (I feel morally obliged to separate my waste; It goes against my principles to not separate my waste; It gives me a good feeling if I try to separate my waste) (De Groot and Steg, 2009). Personal norm was measured at t1, t2, and t3. Cronbach's alpha was 0.82, 0.83, and 0.87.

Our study had a quasi-experimental design, participants were not randomly assigned to the intervention group or control group. Therefore, we tested if the two groups differ on the key variables in the pre-measure situation. We found that participants in the intervention group (M = 5.10, SD = 1.05) reported to prevent waste more than the control group (M = 4.72, SD = .99; t(357) = -3.45, $p < 0.01$). We did not find significant differences on separating waste and residual waste (both $ps > .05$). The intervention group (M = 4.93, SD = 1.29) reported a stronger awareness of consequences than the control group (M = 4.62, SD = 1.36; t(350) = -2.17, $p < 0.05$). Outcome efficacy did not differ between the intervention and control group ($p > 0.05$). The intervention group (M = 6.04, SD = 1.06) reported a stronger personal norm than the control group (M = 5.67, SD = 1.26; t(350) = -2.97, $p < 0.01$).

4. Results

Multilevel modelling for repeated measures was used to test differences between the control group and the intervention group over time in separating waste, residual waste, and waste prevention. Multilevel modelling does not require data on all measurements for each individual, but uses all observed measures. Therefore, all 409 participants were included. The observations (level 1) are nested within individuals (level 2). We used t1 (the premeasure) as the reference group and compared it to t2, t3, and t4. For all self-reported waste behaviours, a random intercepts model with variance components as the covariance structure was executed. The effects of time (t2, t3 and t4) were added and the effects of groups (intervention), as well as interaction effects between the intervention and time (t2xintervention, t3xintervention, t4xintervention).

We expected the interaction effects to be significant. That is, we expected the intervention group to significantly increase waste separation and waste prevention from t1 to t2, t3 and t4, while we expected no change in the control condition from t1 to t2, t3, and t4. We expected residual waste to significantly decrease from t1 to t2, t3 and t4 in the intervention group, while we expected no change in the control group from t1 to t2, t3 and t4. Furthermore, we expected awareness of consequences, outcome efficacy, and personal norm to significantly increase from t1 to t2 and t3 in the intervention group, but we expected no significant changes in the control group from t1 to t2 and t3.

For separating waste there were only significant effects of time. Overall, participants separated more waste at t2, t3 and t4 compared to t1 (see Table 5 and Fig. 3). No significant effects of the intervention were found. There were also no significant interaction effects.

For waste prevention a significant effect at time 3 was found: participants were more likely to prevent waste at time 3 compared to time 1 (see Table 5 and Fig. 4). There was also an effect of the intervention. Participants in the intervention group were more likely to prevent waste compared to participants in the control group. All of the three

Table 5
Results for Separating waste, Preventing Waste, Residual waste over time, per condition and its interaction.

Fixed effects	Separating waste			Preventing waste			Residual waste		
	Est.	SE	t	Est.	SE	t	Est.	SE	t
Intercept	5.47	.08		4.72	.07		161.20	11.82	
Mean diff. (t1 vs t2)	.75	.10	7.75***	.02	.05	.45	46.37	12.98	3.57***
Mean diff. (t1 vs t3)	.75	.10	7.63***	.12	.05	2.26*	46.27	13.13	3.52***
Mean diff. (t1 vs t4)	.86	.10	8.30***	.05	.06	.81	22.50	13.95	1.61
Intervention	.02	.12	.14	.36	.10	3.79***	−33.70	16.41	−2.05*
t2 * intervention	.20	.14	1.40	.42	.08	5.31***	−117.80	19.30	−6.10***
t3 * intervention	.25	.14	1.72	.37	.08	4.67***	−108.52	19.39	−5.60***
t4 * intervention	.22	.17	1.29	.52	.09	5.58***	−63.96	22.75	−2.81**
Between individual variance	.51	.06	.68	.05		11479.66	1206.69		
Measurement variance	.74	.04	.21	.01		13053.53	693.42		

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

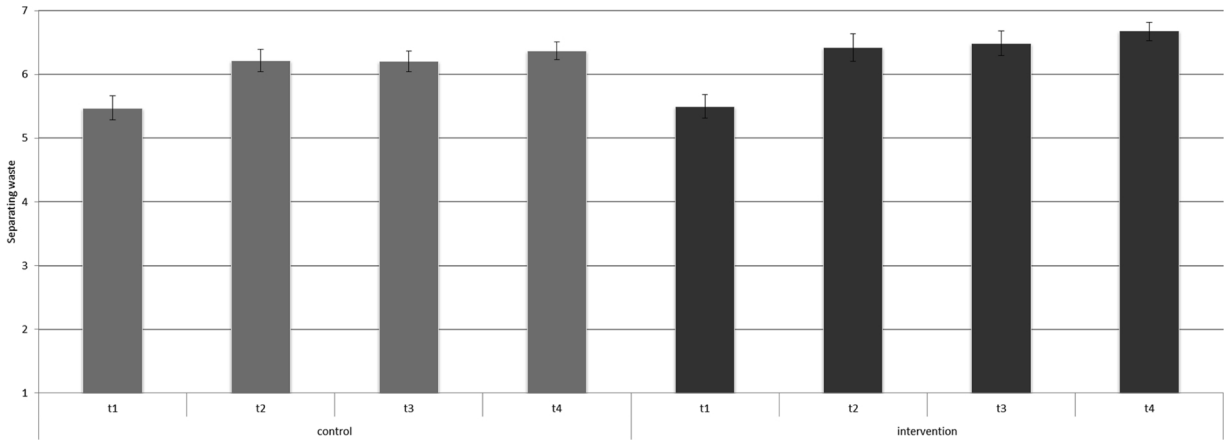

Fig. 3. Means of self-reported separating waste over the four measurements per intervention group including the 95% confidence interval.

interaction effects were significant. In line with our hypotheses, the intervention group increased waste prevention behaviour more than the control group at t2, t3 and t4 compared to t1 (see Fig. 4).

Significant effects of time were found for residual waste. Participants reported lower residual waste at time 2 and 3 compared to time 1. No significant differences were found between time 1 and time 4 (see Table 5 and Fig. 5). There was also no significant effect of the intervention. Overall, the intervention group reported lower residual waste than the control group. All three interaction effects were significant. In line with our hypotheses, the intervention group decreased residual waste more than the control group at t2, t3 and t4 compared to t1.

Next, it was tested if the households receiving the informational strategy, reduced their actual waste volume. Statistical analyses could not be performed as residual waste was measured at the group level. It was found that the total amount of kilograms of residual waste among households in the informational strategy group reduced with 4.00 kg/person compared to the situation before the intervention (see Table 6). Furthermore, the amount of incorrectly sorted residual waste reduced by 2.83 kg/person. The average Dutch inhabitant produces 158 kg of residual waste per year (Statline, 2017).

4.1. Process underlying the intervention

It was tested if the changes in waste behaviour are explained by changes in the variables from the norm activation model. Multilevel analyses were conducted to test if the intervention influenced awareness of consequences, outcome efficacy and personal norm. Again, the observations (level 1) are nested within individuals (level 2). T1 was used as the reference group and compared to t2, and t3. A random intercepts model with variance components as the covariance structure was executed. The effects of time (t2, and t3) and the effects of groups (intervention) were added, as well as interaction effects between the intervention and time (t2xintervention, t3xintervention).

No effects of time for awareness of consequences were found (see Table 7 and Fig. 6), however, an effect of the intervention was found. Overall, the intervention group reported a stronger awareness of consequences than the control group. Significant interaction effects were found. In line with our hypotheses, participants in the intervention group increased awareness of consequences more from t1 to t2 and from t1 to t3 than the control group. For outcome efficacy, no main effects of time and the intervention were found (see Table 7 and Fig. 7). However, the expected interaction effect was found. Outcome efficacy increased more from t1 to t2 in the intervention group than in the control group. An effect of time was not found for personal norms. We found an effect of the intervention on personal norms. Participants in the intervention group reported a stronger personal norm than participants in the control group (see Table 7 and Fig. 8). Furthermore, an interaction effect was found. Personal norms increased more from t1 to t3 in the intervention group than in the control group.

Next, it was tested if the informational intervention influenced the increase in reducing waste and residual waste via the variables from the norm activation model. Mediation analyses were conducted using Hayes' (2013) process model. The difference scores from the pre-measure to the first post measure (t2 – t1) were used as the behaviours changed most from time 1 to time 2. The difference scores for awareness of consequences (M = 0.19, SD = 1.29), outcome efficacy (M = 0.22, SD = 1.19), and personal norm (M = 0.12, SD = 0.96) were

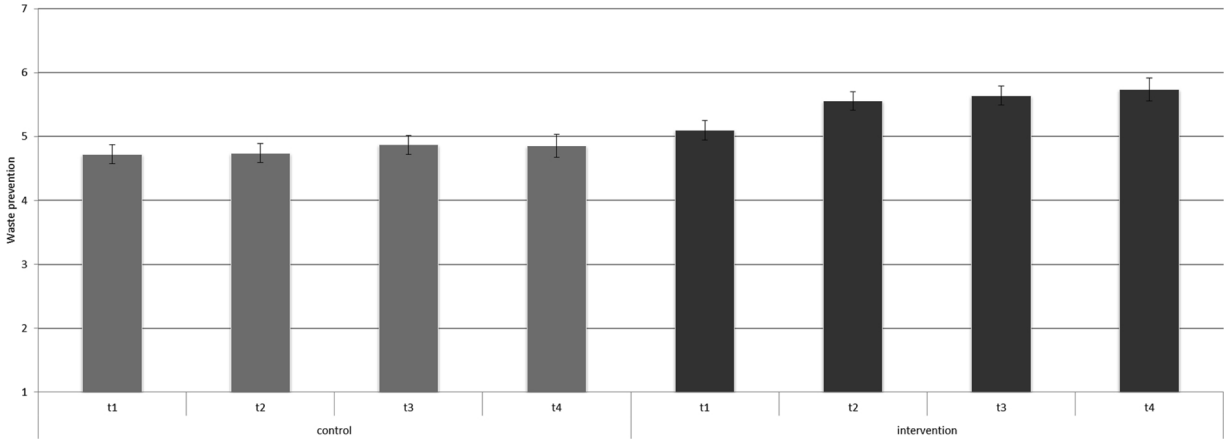

Fig. 4. Means of self-reported waste prevention over the four measurements per intervention group including the 95% confidence interval.

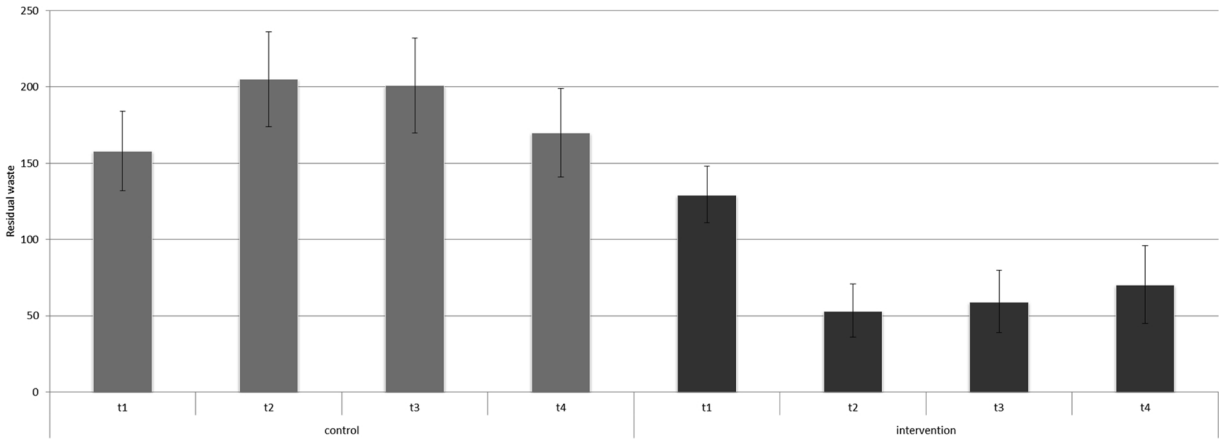

Fig. 5. Means of self-reported residual waste over the four measurements per intervention group including the 95% confidence interval.

Table 6
Actual residual waste of a random selection of households receiving the informational strategy in kilograms per inhabitant per year.

	t1	t3
Residual waste	36.56	32.56
Incorrectly sorted residual waste	6.19	3.36

calculated. We also calculated the change in the outcome variables (t2 – t1), i.e. reducing waste (M = 0.19, SD = 0.69), and residual waste (M = -0.66, SD = 195.24). The influence on separating waste was not tested as the analyses showed that the group receiving the informational strategy did not differ from the control group in separating waste over time. Model 6 in Hayes' macro was used including the measures of awareness of consequences, outcome efficacy, personal norms and the dependent variable as covariates.

As depicted in Fig. 9 and Table 8 the informational strategy influenced the reduction of waste via the variables of the norm activation model. The influence of the intervention on waste reduction was mediated by awareness of consequences, outcome efficacy and personal norm. However, there was still a direct effect of the informational strategy on reducing waste. This means we found complementary mediation, suggesting that there may be other mediators as well (Zhao et al., 2010).

As shown in Fig. 10 and Table 9, the influence of the informational strategy on the reduction of residual waste was mediated by some of the variables from the norm activation model. The influence of the informational strategy on waste reduction was mediated by awareness of consequences and outcome efficacy. Personal norms did not mediate the relationship between the informational strategy and residual waste. Still, the informational strategy significantly influenced residual waste when these mediators where included suggesting complementary mediation (Zhao et al., 2010). Again this suggests that there may be other mediators as well.

5. Discussion

The current paper tested the effectiveness of an innovative informational intervention strategy aiming to promote waste minimization. Importantly, the effects on several waste minimization outcomes were examined. Furthermore, the underlying process explaining the influence of the informational strategy on waste minimization was tested. The results show that the informational strategy effectively reduced households' waste. The informational strategy influenced behaviour partly by increasing the variables from the norm activation model.

5.1. The effect of the informational strategy

The informational intervention strategy, consisting of tips and assignments to reduce residual waste and focusing households on the problems caused by waste, helped to promote waste minimization. Our findings are in line with earlier studies showing that informational strategies can promote waste minimization (Bowman et al., 1998; Dai et al., 2015; Grodzińska-Jurczak et al., 2006; Hopper and Nielsen, 1991; Iyer and Kashyap, 2007; Lord, 1994; Read, 1999). However, they are not in line with other studies showing that informational strategies may not effectively minimize household waste (Bernstad, 2014; Bernstad et al., 2013; Chong et al., 2013; Dupré, 2014; Goldenhar and Connell, 1991; Schultz, 1999; Timlett and Williams, 2008). The informational strategy studied in the current paper, may have been effective because it actively engaged households. Households received weekly assignments related to their waste and had the opportunity to provide each other with tips via an online platform. Previous studies including informational strategies often provide information once (Varotto and Spagnolli, 2017), while the intervention tested in the current paper

Table 7
Results for Awareness of consequences, outcome efficacy, and personal norm over time, per condition and its interaction.

Fixed effects	Awareness of consequences			Outcome efficacy			Personal norms			
	t	Est.	SE	t	Est.	SE	t	Est.	SE	t
intercept		4.58	.10		5.47	.09		5.61	.09	
Mean diff. (t1 vs t2)	3.57***	−.03	.10	−.27	.04	.09	.44	.04	.07	.61
Mean diff. (t1 vs t3)	3.52***	−.07	.10	−.72	.11	.09	1.20	−.05	.07	−.75
Intervention	−2.05*	.32	.14	2.26*	.23	.12	1.92	.42	.12	3.55***
t2 * intervention	−6.10***	.43	.15	2.98**	.37	.13	2.83**	.21	.11	1.95
t3 * intervention	−5.60***	.60	.15	4.05***	.23	.13	1.79	.40	.11	3.68***
Between individual variance		1.08	.10	.75	.07			.94	.08	
Measurement variance		.72	.05	.57	.04			.40	.02	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

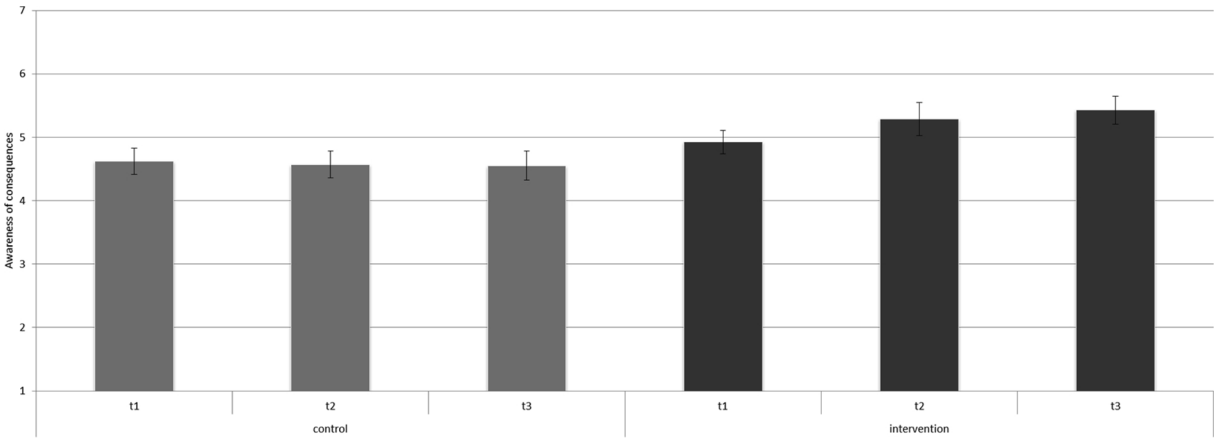

Fig. 6. Means of awareness of consequences over the three measurements per intervention group including the 95% confidence interval.

provided people with information every week during a period of 100 days. Also, households could continuously interact via the online platform, providing a unique interactive environment for participants. However, despite such an involving strategy the changes in behaviour in our study were relatively limited (see below). Future research can more systematically test which elements of informational strategies promote sustainable waste behaviour. For example, it could be tested to what extent (online) interaction between participants contributes to waste minimization. Also, future research could test how frequently information needs to be provided in order to be effective in minimizing waste. Finally, many studies testing the influence of an informational strategy on waste are relatively old. As the circumstances regarding waste such as collection systems may have changed more research is needed to test the influence of an informational strategy on waste minimization in the current situation.

Previous research suggests that the effectiveness of interventions may disappear when they are removed (Porter et al., 1995). Therefore, the current study measured waste minimization during the 100 days that the intervention was in place and six months after it ended. Our findings show that the informational strategy promoted waste minimization during the intervention period and the change in behaviour was still evident, six months after the intervention ended.

Previous studies have mostly focused on an increase in recycled materials when testing the effectiveness of interventions. However, to reduce environmental problems households should not only separate waste, but also change purchasing behaviour. We tested and found that the intervention increased self-reported waste reduction behaviour and decreased self-reported residual waste. Furthermore, participants in the intervention group reduced the average volume of residual waste (measured as annual kilograms per person) over time. Our findings therefore suggest that informational strategies can reduce residual waste generation. However, we collected and analysed actual residual waste on the group level in the intervention group and not in the control group. Therefore, it is not possible to fully statistically compare these groups. Future research could aim to collect actual residual waste data on a household level for the intervention as well as the control group.

Interestingly, households receiving the informational strategy separated their waste more after the intervention, but so did the control group. This may be explained by the fact that during the same period a (national) recycling scheme was introduced that provided households with the opportunity to recycle more waste, i.e. allowing the separate collection of metal packaging waste and drinking and beverage cartons. Thus, factors beyond the influence of households (and of this project) may also have influenced waste minimization. Indeed, waste behaviour depends on individual factors, e.g. motivation, and contextual factors, e.g. the recycling scheme (Guagnano et al., 1995). Future research could address the interaction between contextual factors and individual factors. Alternatively, the questionnaire on waste and recycling behaviour may have motivated the control group to better separate waste. Perhaps filling out a questionnaire on waste may already stimulate people to improve waste separation. Changing households purchase behaviour may be more difficult to change than separating waste. Therefore, filling out a questionnaire may not influence households' purchases. Future research is needed to test if recycling may indeed be promoted more easily than waste reduction.

Our results show that the households receiving the informational strategy increased waste minimization compared to the control group.

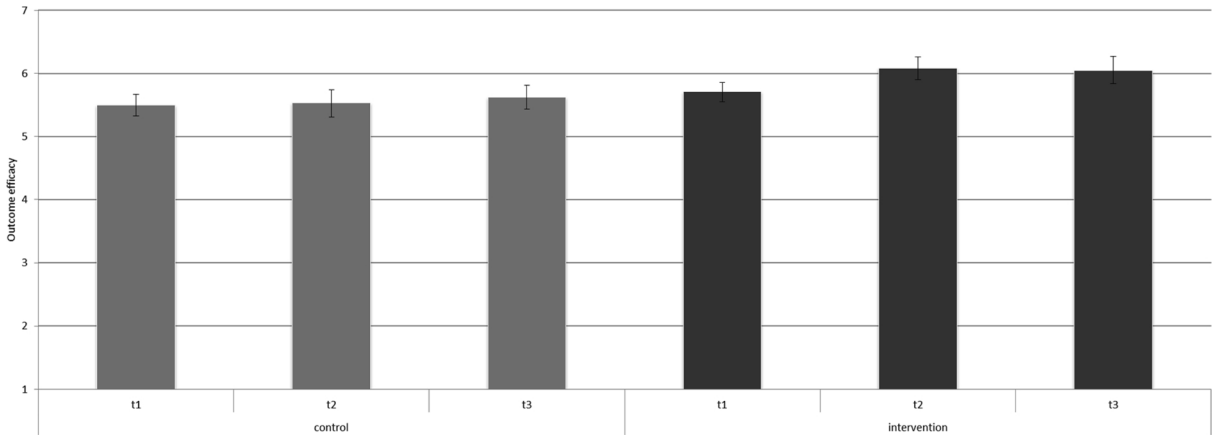

Fig. 7. Means of outcome efficacy over the three measurements per intervention group including the 95% confidence interval.

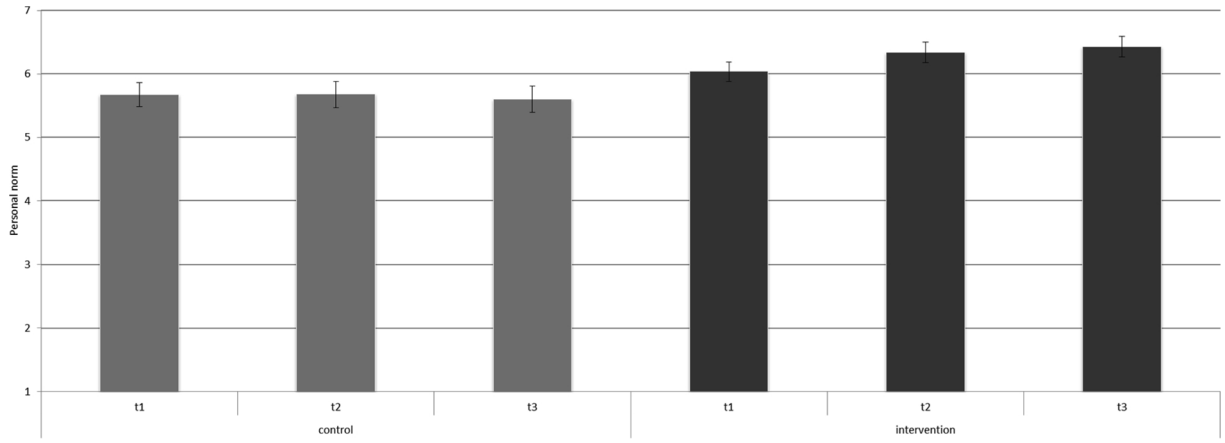

Fig. 8. Means of personal norm over the three measurements per intervention group including the 95% confidence interval.
***p < .001, ** p < .01, * p < .05.

However, households were not randomly selected or assigned to the intervention or control group. The organisation initiating the intervention recruited the households by promoting it as the "100-100-100 Challenge". Therefore, households were pre-informed about the goal of the intervention that it aimed to make 100 households 100% waste free for 100 days. Households who signed up for this challenge could therefore not be included in a control group. The control group was established by contacting households via email that had indicated before that they would be willing to participate in studies by ROVA. The households signing up for the "100-100-100 Challenge" differed from the households in the control group on some variables in the pre-measure. Households in the intervention group had significantly stronger awareness of consequences, personal norms, and waste reduction behaviour than in the control group before the start of the intervention. However, importantly, these variables increased in the intervention group from the pre-measure to the following measuring moments, while they did not increase in the control group. There were no significant initial differences between the groups in outcome efficacy, recycling behaviour, and self-reported volumes of residual waste. Actual residual waste reduced as well in the intervention group. However, the actual amount of residual waste of the participants in our study was much smaller compared to the average Dutch person. Although actual waste was only measured over a couple of weeks and not the entire year it suggests that our participants produce less waste than average. The small amount of actual waste may explain the relatively limited impact of the project within the intervention group. However, despite the limited saving potential of these participants the intervention group still reduced their waste following the intervention. Future research is needed to test if the informational strategy promotes waste minimization when participants do not actively sign up for the intervention and when they are randomly assigned to conditions. Future research could also test if informational strategies lead to more waste minimization among other samples, including participants with a larger saving potential.

Table 8
The indirect effects of the strategy on waste reduction via awareness of consequences, outcome efficacy and personal norms.

Indirect Effects				
	Effect	BootSE	LL95%CI	UL95%CI
Total	.07	.03	.02	.13
Int. → AC → WR	.02	.03	−.03	.08
Int. → AC → OE → WR	−.00	.02	−.04	.03
Int. → AC → PN → WR	.01	.01	.00	.03
Int. → AC → OE → PN → WR	.02	.01	.00	.05
Int. → OE → WR	−.00	.01	−.02	.01
Int. → OE → PN → WR	.01	.01	−.00	.03
Int. → PN → WR	.01	.01	−.01	.05

Note. Int. = intervention, AC = awareness of consequences), OE = outcome efficacy), PN = personal norm, WR = waste reduction.

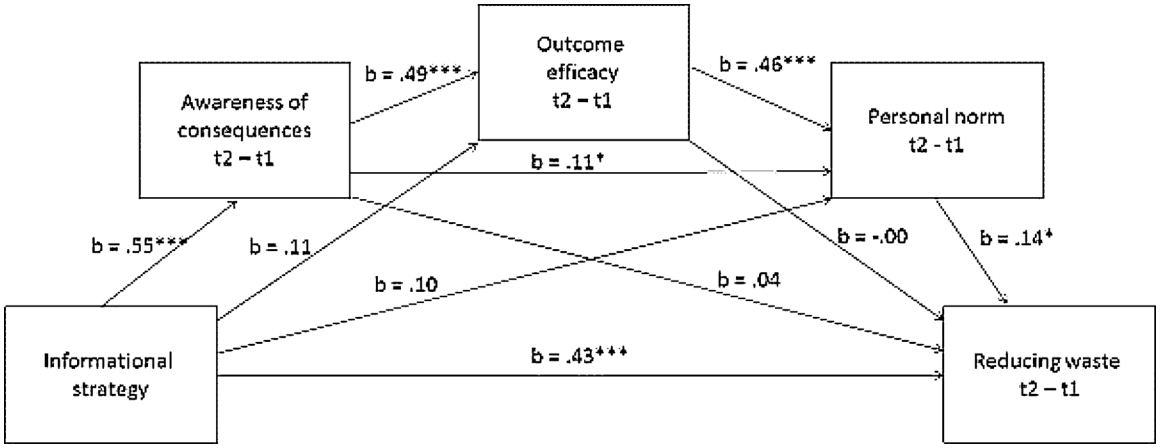

Fig. 9. The relationship between the intervention and reducing waste via the variables from the norm activation model.
***p < .001, ** p < .01, * p < .05.

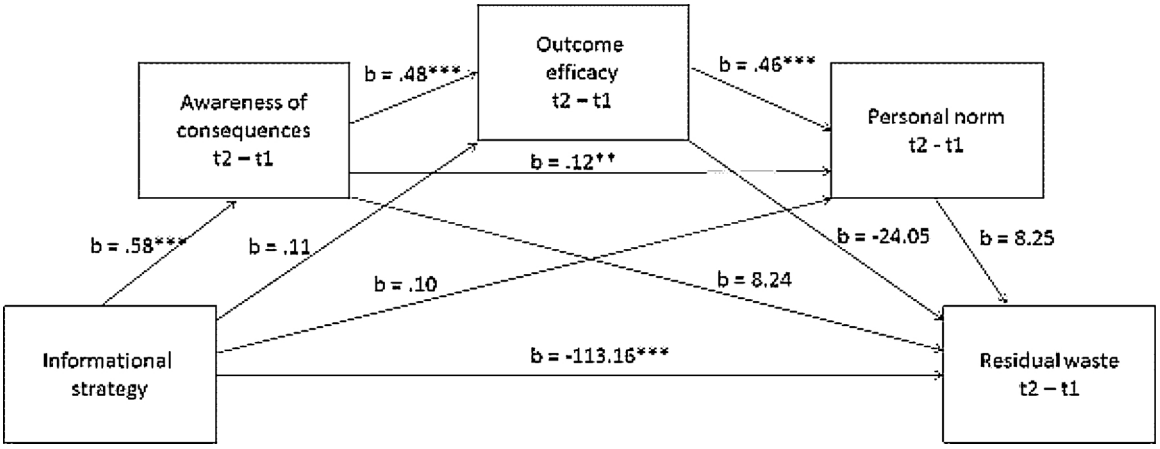

Fig. 10. The relationship between the intervention and residual waste via the variables from the norm activation model.

Table 9
The indirect effects of the strategy on residual waste via awareness of consequences, outcome efficacy and personal norms.

Indirect Effects				
	Effect	BootSE	LL95%CI	UL95%CI
Total	−1.84	7.95	−18.04	13.29
Int. → AC → RW	4.78	6.71	−5.93	21.27
Int. → AC → OE → RW	−6.75	4.75	−19.91	−.34
Int. → AC → PN → RW	.55	1.21	−1.23	3.97
Int. → AC → OE → PN → RW	1.06	2.40	−2.65	7.39
Int. → OE → RW	−2.74	3.47	−13.17	1.62
Int. → OE → PN → RW	.43	1.26	−.86	5.25
Int. → PN → RW	.82	2.29	−1.84	8.51

Note. Int. = intervention, AC = awareness of consequences), OE = outcome efficacy), PN = personal norm, RW = residual waste.

5.2. Informational strategy and the norm activation model

Interestingly, our results show that the informational strategy increased waste minimization because the variables from the norm activation model were increased. More specifically, waste minimization increased because people were more aware of environmental problems caused by a lack of waste separation, felt their behaviour is more likely to reduce these problems and felt morally obliged to separate the waste. The intervention influenced households' waste minimization via all variables from the norm activation model. However, the intervention reduced residual waste via awareness of consequences and outcome efficacy. Personal norm did not mediate the relationship between the informational strategy and residual waste. Previous research was inconclusive with regard to the variables from the norm activation model as explaining the effect of an informational strategy. Some studies did not find effects of the informational strategy on the variables from the norm activation model (Dai et al., 2015; Hopper and Nielsen, 1991), while one study did (Quested et al., 2011). However, previous studies did not include all variables from the norm activation model. Our findings suggest that an informational strategy minimizes household waste because particularly awareness of consequences and outcome efficacy are strengthened. Future research is needed to replicate our findings, for example in other countries. Furthermore, future research could test which types of information are most likely to increase the variables from the norm activation model. Our strategy included tips on waste reduction, weekly assignments, and a contract that participating households signed. Future research could systematically test which elements from the intervention are most likely to increase the variables from the norm activation model and thereby promote waste minimization.

Our findings suggest that other mediators may explain the relationship between the informational strategy and waste minimization as well in addition to the variables from the norm activation model. Future research could test other possible mediators. For example, strategies may increase the extent to which people feel able to change their waste behaviour (Schmidt, 2016; Geiger et al., 2017). Future research could test if an informational strategy may also influence the extent to which people feel able to reduce waste or their knowledge to reduce household waste.

The findings could also be affected by the way the variables were measured. We measured the variables from the norm activation model focusing on waste separation. However, the tested strategy affected the households' purchasing behaviour and their residual waste. Behaviour is most strongly influenced by factors that are measured on the same level of specificity (Ajzen, 1996). Future research could therefore measure the variables from the norm activation model focussing on waste minimization and test if an informational strategy influences waste minimization behaviours via these variables.

6. Conclusion

We found that an innovative informational strategy consisting of active engagement (e.g. a contract, an online platform, tips on reducing waste, weekly assignments, and comparisons of waste) was effective in promoting waste minimization by households even after the intervention was removed. The strategy influenced waste minimization particularly by increasing awareness of consequences and outcome efficacy. These findings contribute to the literature by providing more insight into why informational strategies may minimize waste. However, future research is needed to replicate our findings among other samples and using a randomized experimental design. Furthermore, future research is needed to systematically test which elements of an informational strategy contribute most to waste minimization. Our findings have important implications for practitioners aiming to promote waste minimization, suggesting that if information increases the extent to which people are aware of the problems caused by their waste and feel that their behaviour contributes to solving the problem, households will minimize their waste. An informational strategy may be more likely to do so when households are actively engaged, e.g. by receiving assignments that make them aware of problems and interacting with others, and if the intervention takes place over a longer period of time.

Acknowledgements

We would like to thank ROVA for the opportunity to perform this research during and after the "100-100-100 Challenge" project. We particularly would like to thank the project leader Natascha Spanbroek

for her enthusiasm and hard work that helped making the project a success. We would like to thank Huibert Boer, Anne Oosterwijk and Mark Leemans for their continuous support throughout the project. We would like to thank EURECO for the waste sorting analysis. Finally, we would like to thank all participating households for making this project possible.

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