The Use of Feedback to Enhance Environmental Outcomes: a Randomized Controlled Trial of a Food Waste Scheme

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Abstract

Food waste makes up about twenty per cent of general waste that goes to landfill every year. Encouraging the public to engage in food waste recycling and diversifying more food waste from general waste could help councils save resources as well as promote a better environment. Theory suggests that appeals to collective norms, by giving people feedback on their street's food waste recycling rate compared to others, could promote recycling behaviour. We carried out a randomised controlled trial to test how to involve the public into the newly introduced food waste recycling service in Oldham, Greater Manchester. The 318 streets were randomly assigned into a treatment and control group for the experiment. All households in the treatment group were sent two postcards providing feedback on how their street performed on food waste recycling compared to the average for their neighbourhood. Participation in the food waste scheme was measured for all households on three occasions: at baseline, and after the receipt of the first and second feedback cards. We estimated the effect of our treatment using cross-classified multilevel logistic regression models, controlling for baseline, street size, and interaction term of treatment and baseline, show that feedback had a positive effect on the food waste participation and the effect at individual level varied between streets. We find that the provision of feedback on street level performance had a positive impact on participation in a food waste scheme and the effect size was 2.8% compared to a control group that received no treatment.

1. Background

Councils need to reduce the amount of household waste going to landfill, and an important, but often neglected component, is food. Whilst kerbside collections of green waste, paper/cardboard, bottles and cans are now widely established, there are only just over 100 UK local authorities that have introduced food waste collection schemes (Bridgewater and Parfitt 2008). Disposal of biodegradable waste to landfill results in emissions of methane, one of the powerful greenhouse gas emissions that contribute to global warming. Food waste - together with other biodegradable waste such as green waste, paper and cardboard - comprise about 3% of UK methane emissions. At the same time, the UK government has set a new target to divert food waste from landfill disposal; by 2010, biodegradable municipal waste going to landfill must be 75% of the amount produced in 1995; by 2013 this reduces to 50% and by 2020 to 35% (DEFRA 2007). It is an urgent priority for local authorities, which have responsibility for waste disposal in the UK, to achieve significant reductions in the quantity of rubbish sent to be buried in landfill sites. There is an incentive also for councils to divert food waste from general waste. First, general waste from households contains, on average, 17 per cent food waste. That is the third largest biodegradable content after garden waste and paper (WRAP, 2002). Diversion of food waste will help reduce the total amount of general waste that goes to landfill. Second, the cost per tonne of food waste disposal is cheaper than the cost per tonne of general waste disposal for councils to pay. Third, it is a re-use of resource as food waste is composted and re-used as organic fertiliser. Thus there are good reasons for councils to introduce food waste recycling schemes. However, there is still very scarce information about what affects participation in food waste schemes and what could promote the participation rate.

1.1 The Influence of Social Norms

The existing literature suggests that participation in recycling schemes can be encouraged by a number of means including door-to-door canvassing (Cotterill, John, Liu and Nomura, 2009), promotional campaigns (Read 1999), use of existing recyclers as role models (Bryce, Day et al. 1997) and feedback cards left by the crew (Timlett and Williams 2008). They suggest - though do not test directly - that it might be possible to change recycling behaviour by activating these personal or social norms. To this end, the research develops and applies Schwartz's 'norm-activation theory' that sees moral behaviour as a result of a personal norm to act in a particular way (Schwartz 1968). These norms arise, according to Schwartz, from an awareness of the consequences of one's actions and the ability and willingness to assume responsibility for those consequences. In an attempt to explain the influence of social norms, Tajfel and Turner (1979) and their colleagues (Tajfel 1978; Turner and Giles 1981; Hogg and Abrams 1988) developed a theory of intergroup behaviour which is based on the premise that social identification with a reference group is a key component of identity. This social identity is defined in terms of 'the individual's knowledge that he belongs to certain social groups together with some emotional and value significance to him of the group membership' (Jackson 2005: 79). It incorporates the ideas which regard key aspects of our behaviour as being motivated by a tendency towards intra-group solidarity and inter group competition (Ellemers, Kortekas et al. 1999). Previous evidence suggests that group feedback works better than other forms of feedback (Schulz 1998).

What we do not know in reference to our study is whether individuals feel solidarity at the street level that prompts them to cooperate to improve their recycling compared to the area average. In other words, is street regarded as 'reference group'? Are individual households influenced by the recycling performance of their own street? Thus the study tests this very point of whether giving people feedback on their street recycling rate compared to

others may create a sense of identity and therefore could promote recycling behaviour. To test this claim, we randomly assigned households to a treatment or a control group. We provided households in the treatment group with postcards giving feedback on the recent recycling performance of their street compared to the neighbourhood average, while the households in the control group received no special attention. If the households that receive feedback improve their food waste recycling participation more than those in the control group, it means feedback helps promote participation. It is possible that such effort is just due to each individual. Or possibly the provision of feedback on their street participation rate could prompt a sense of identification with others on the same street. We can examine to what extent this improvement is an individual and/or a street effect.

1.2 The Importance of Feedback

The rationale behind the feedback approach is that most people underestimate the extent of pro-social behaviour among their peers and then use those low estimates as a standard against which to judge themselves (Schultz, Jessica et al. 2007). This is the "descriptive norm" (Cialdini, Kallgren et al. 1991). Providing feedback on the actual rates of pro-social behaviour amongst peers offers a point of comparison, which "acts as a magnet for behaviour for individuals both above and below the average" (Schultz, Jessica et al. 2007: 430).

The provision of written feedback on the election turnout of near neighbours had a substantial impact on encouraging voters to go to the polls: among citizens who were given information on whether their neighbour's voted in previous elections, 37.8% turned out to vote, compared to a turnout of 29.7% among a control group who did not get the information, and a 31.5% turnout among those who received a simple message urging them to vote. However, this high effect size of 8.1% is linked to a shaming element to the intervention:

households were told that their voting behaviour was being monitored and would be made public to their neighbours after the election (Gerber, Green et al. 2008).

Overall, feedback is expected to lead to a general rise in pro-social behaviour by letting people know that the prevalence amongst their peers is higher than they thought. However, previous studies show mixed results. The provision of feedback leaflets to households giving borough-wide recycling participation rates had no effect in changing householder behaviour in a London borough, regardless of whether the feedback was presented in a positive, negative or neutral way (Lyas, Shaw et al. 2004). By contrast, in a US field experiment, the provision of more specific feedback which states the recycling activity of the individual household or the surrounding streets during the current or previous week was successful in raising the frequency of participation and the amount of material recycled (Schulz 1998).

Feedback may have an unintended 'boomerang effect' (Schultz, Jessica et al. 2007: 430) on those who already undertake pro-social behaviour, by alerting them that they are deviating from the norm. One solution to this is to go beyond the provision of information and invoke the injunctive norm, perceptions of what is commonly approved or disapproved within society (Reno, Cialdini et al. 1993) to counteract the boomerang effect. Such an approach was tested in a field experiment on household energy use: adding an injunctive component to feedback cards in the form of a smiley face ☺ or frown face ☹ countered the boomerang effect, encouraging both above average consumers to reduce their energy use and below average consumers to continue their low consumption rates (Schultz, Jessica et al. 2007: 430). Thus for this experiment, we provide feedback with either a smiley or frown face to promote participation in the food waste collection scheme.

In the next section we describe the research design and methods, including the objectives of the research, the site of the study, details of the population and how it was randomised, a

description of the feedback intervention, an explanation of how participation was measured, and a description of our data. In the following sections we present the results of the research, both descriptive findings and the results from multilevel mixed-effects logistic regression. We then discuss the results and offer some conclusions. Throughout the paper we follow the CONSORT guidelines on how to report randomised controlled trials (Moher, Schulz, & Altman, 2001). We find that the provision of two feedback cards on street level performance had a positive impact on participation in a food waste scheme and the effect size was 2.8% compared to a control group that received no treatment. The feedback cards were successful in raising participation levels in both high performing and low performing streets. Baseline recycling rates are a strong predictor of later recycling participation: once households get into the habit of recycling, they carry on doing it. However, in this study we found that feedback had a negative effect on existing recyclers: feedback works best on those households that do not currently recycle their food waste. We see a street effect: those living on smaller streets are more likely to be affected by the intervention.

2. Research Design and Methods

2.1 Research objectives

The main objective of the research is to test whether activating the collective norm by giving people feedback on their street participation rate compared to others can promote environmental behaviour. We expect that the treatment group will have a higher level of participation in the food waste scheme than the control group (H_1). A second objective is to test whether feedback is equally successful in its impact on streets with below and above average base participation rates. We expect that the inclusion of the smiley and frown faces on the feedback will counter the boomerang effect, so the low performing streets will

increase their participation (H_2) and the high performing streets will at least maintain their current levels of participation (H_3). Finally, if individuals feel solidarity at the street level to prompt them to cooperate and work together to improve their recycling compared to the area average, this effect would diminish as streets become longer (H_4). We should also see correlation effects of individual level and street level. Thus we use street and area level variables to test their effect on the participation rate.

2.2 Oldham Council Food Waste Collection Scheme

Oldham is a former mill town in the Greater Manchester area, bordering with Yorkshire. About 97 per cent of the population is white and most ethnic minorities living in the area are UK-born. The Waste Management Group of Oldham Council provides waste collection services to all households in the borough; fortnightly collections of green waste, recyclables (paper, card, plastic bottles, aluminium cans, and glasses), residual waste and a weekly food waste collection. Currently Oldham Council collects food waste from about 89,000 properties. In late 2009, approximately 400 tonnes of food is estimated to be recycled per month by Oldham residents. The collected food waste is composted and the compost is then used on agricultural land. Among the nine councils in Greater Manchester, Oldham is the first to try out a food waste collection scheme. Oldham council introduced the food waste recycling scheme first to one area in Oldham as a pilot case in October 2007, and then introduced it to the rest of Oldham in phases between November 2008 and June 2009. As it was only recently introduced, there has not yet been a study on the performance of the scheme.

Oldham has already seen evidence of the positive results of introducing the recycling scheme. Prior to the introduction of the scheme, the total waste that Oldham generated during

the fiscal year of 2006/2007 consisted of 85% general waste, 6% garden waste, 5% paper and cardboard, and 4% glass, cans and plastic bottles. Since the introduction of the food waste recycling scheme, in the fiscal year 2008/2009, the total waste generated 68% general waste, 7% garden waste, 8% papers and cardboard, 14% glass, cans and plastic bottles, and 3% food waste. In terms of tonnage, general waste was reduced by approx. 14,000 tonnes from 68,000 tonnes to 54,000 tonnes whereas the tonnage of food waste generated was 2,000 tonnes. The reduction of general waste was also attributed to the increase in the total amount of glass, cans and plastic bottles recycled during the year. The cost for the disposal of general waste per tonne is about 85 pounds and that of food is 52 pounds as of 2009. The reduction of 14,000 tonnes of general waste means a saving for 1,190,000 pounds for the council. Even we consider the cost incurred by the management of recyclable substances, this saving is quite remarkable. This indicates that more participants into the scheme could help reduce general waste further while bringing down the cost of the new scheme per household. Furthermore, as indicated in the Waste Strategy 2007 for England, Greater Manchester has recently been granted a Private Finance Initiative (PFI) to build the infrastructure necessary to promote more recycling in the area. Signed in April 2009, a £640 million PFI intends to promote Greater Manchester's recycling rate from 30 per cent to 50 per cent by 2015. The main project is the creation of a recycling centre including compost facility to help increase the city's recycling rate. Once it is built, it is likely that other Manchester councils will introduce food waste collections and compost the waste at the centre. Understanding factors that affect food waste recycling performance in the Oldham will be of likely benefit to the other councils in Greater Manchester, as well as other parts of the country.

2.3 The intervention

We used feedback cards as the treatment. Each household in the treatment group was delivered a postcard providing feedback on how their street performed compared to the average for their neighbourhood. The leaflet stated: "Did you know: X% of homes on A Street recycle their food waste. The average for the area is Y%". It included either a smiley face ☺ or a frown face ☹, depending on whether the street was better or worse than the neighbourhood average and it concluded with the message: "With your help your street could become the best recycling street in Oldham". On the reverse were details of how to participate in the food waste scheme. The contents of the card were tailored to each street, and were produced using the data we had gathered from the participation monitoring. The feedback postcards were delivered twice: once during the week after the first round of participation monitoring and again the week after the second round of monitoring.

2.4 Outcome measurement

In collaboration with Oldham Council and EMERGE Recycling, we monitored the participation rate of all the households in both the treatment and control groups, a total of 318 streets with 9,082 households. We measured participation by observing which households put out a food waste container for collection. The monitoring was done on the same day as the food waste collection. The monitors travelled ahead of the collection crew and noted all the houses on the street that had placed a food waste bin outside the house boundary. The monitoring was repeated over three consecutive weeks: some households may not leave out food waste weekly because of holidays or having low levels of waste. Any household who put out a container at least once in the three-week period counts as a recycler, following the

most recent guidance from the Waste and Resources Action Programme, supported by the environment department, Defra, (WRAP, 2006).

Participation in the recycling scheme was measured for all households in the intervention and control groups at three time points: in August 2009 prior to the feedback campaign, in September 2009 after the delivery of the first feedback postcard and in October 2009 after the second postcard. The participation monitoring and the delivery of the feedback cards were conducted by monitors who were specifically recruited for this task, employed by Emerge recycling. The monitors were aware of the experiment and they were advised not to speak to the residents about the research in order to avoid contamination. They had no intellectual or financial interest in the study and so were unlikely to have an opinion about the intervention or the outcomes. We therefore felt that this was unlikely to bias the outcomes of the study. Households in both groups were not informed about the experiment and therefore they were not aware of being part of the experiment.

2.5 Sample population and randomisation

The research was undertaken in the autumn of 2009 with a sample of Oldham households: all those households whose waste was collected by the two same collection crews on Wednesday, Thursday and Friday of each week. The households are spread across six separate collection rounds, located in different parts of the town.

As households are clustered in streets, the sample size of street must account for the likelihood of correlation within the clusters. We estimated that we needed at least 93 streets with the average of 60 households in each street for each group to gain 80 per cent of statistical power. Our study population exceeded these calculated requirements: 9082

properties in 318 streets, ranging in size from 1 household to 229 with an average of 62 households per street. We report the CONSORT participant flow diagram in Figure 1.

[Figure 1 about here – CONSORT flow diagram]

We chose the street as the unit of randomisation, which made sense when we were testing the effect of feedback on the collective street food waste participation rate. Randomisation was undertaken after the completion of the baseline participation monitoring. Using the baseline data, the streets were randomly assigned to either the treatment group or the control group. SQL Microsoft. The data was stratified by collection round (6 rounds), recycling performance at baseline (above or below the mean) and street size (long and short) prior to randomisation to ensure that the treatment and control groups contained similar proportions of streets in different areas of Oldham and of different street sizes.[1] The treatment group contained 5009 households in 159 streets and the control group contained 4073 households in 159 streets. The number of the above average or 'smiley streets' is greater than the number of below average or 'frown' streets, because the streets sitting on the median point were included as smiley streets.

Each household on a street in the treatment group was sent two postcards, each of which reflected their street's recycling performance in the previous three weeks. Those on a street with a recycling rate above the neighbourhood mean received a smiley face and those on a street with a recycling rate below the mean received a frown face. Consequently, households in the treatment group could receive the following possible combinations of feedback:

Smiley card at time one – smiley card at time two (smiley-smiley)

Smiley card at time one – frown card at time two (smiley-frown)

[1]. We thank Ben Smith of York Trial Unit who completed the randomisation on our behalf. Randomisation was conducted on the 27th August 2009.

Frown card at time one – frown card at time two (frown-frown)

Frown card at time one – smiley card at time two (frown-smiley)

In the analysis which follows we examine the impact of getting any kind of feedback, comparing all those in the treatment group with all those in the control group and we also compare households in each of the four possible combinations of feedback with counterparts in the control group who live on streets with comparable recycling performance, for example, those living on streets with above average performance at both time one and time two are compared to see the effect of smiley-smiley feedback.

2.6 Data and Variables Used in the Analysis

The 318 streets in Oldham are within the six waste collection areas, boundaries used by the UK office for National Statistics to provide local level data. The dataset has three spatial levels: level one unit is the individual household; level two is the street; and level three is the waste collection area. The data is longitudinal as the participation rate was measured on three occasions: prior to the first intervention, follow-up after the first intervention, and follow-up after the second intervention. The analysis was by intention to treat: we assume that all households received the feedback cards and include all households that were randomised in the final analysis.

The outcome is whether or not households participated in the food waste recycling scheme at least once in the three-week measurement period, a binary measure. The explanatory variables include household level, street level and area level variables. The independent variable (Treatment) is whether household is in the treatment group (1) or not (0).

The household level variable used in the analysis is baseline participation (*baseline*), whether the household participated in the food waste scheme prior to our experiment intervention: participated in (1) and not participated in (0). With recycling, it is likely that baseline will have an effect – households who recycle at T1 will still be recycling at T2 - and a lower baseline will offer more susceptibility to treatment because a campaign is likely to provide information and incentive to act differently.

There are a number of street-level variables. Firstly, the number of households on a street (*streetsize*). Secondly, a series of dummy variables to reflect whether the street is above or below average in its participation in the food waste scheme: those households that are on the above average performing street twice, therefore received smiley face twice (*smiley-smiley*); those that are on the below average street first and then on a above average street at the second round of intervention (*frown-smiley*); and those which are on the below average street twice (*frown-frown*).

There are two area level variables: deprivation score (*deprivation*) and proportion of single person households (*single*). Areas with high deprivation can have lower recycling rates (Cotterill, John, Liu and Nomura, 2009). Households from lower socio-economic groups tend to devote less effort to recycling because their poverty and disadvantage mean they face more pressing needs (Martin et al., 2006). As a covariate, we used Index of Multiple Deprivation (IMD) score for deprivation. For IMD score, higher score means greater deprivation (source: 2007 index, Office for National Statistics). Family structure may affect the participation in the food waste scheme. Single person households can be expected to produce much less food waste than larger households. As a covariate, we used the proportion of single person households, calculated by dividing the total number of single person households by the total population of the super output area (source: 2001 census, Office for National Statistics). For each of the six waste collection areas we calculated the mean IMD

score and proportion of single person households. STATA 10.1 was used as analysis software.

4. Results

4.1 Descriptive Statistics

As Table 1 shows there are area variations in terms of deprivation. The data is compiled based on the mean of super output areas that the six waste collection areas cover. Areas 1 and 2 are the least deprived and have the lowest proportion of single person households. Area 3 is perhaps average area; the deprivation score is moderate, with medium levels of single person households. Areas 4 and 5 have the highest deprivation score among all areas and both have higher proportions of single person households. Area 6 has a medium score of deprivation and medium levels of single person households, compared to the others.

[Table 1 about here]

A comparison of the control group "A" with the treatment group "A" (in Fig 1: CONSORT flow diagram), shows that smiley streets of both groups tended to stay as smiley streets. That is, among 83 smiley streets in the control group, 15 became a frown street; similarly among the 84 streets in the treatment group, 12 became a frown street. But a comparison of control group "C" with treatment group "C" shows that, among 76 frown streets in the control group, only 25 became a smiley street, however, by contrast, among the 75 streets in the treatment group, there was a more substantial shift: 53 streets became a smiley street. This indicates that both the smiley and frown face feedback cards were effective: the positive feedback encouraged those in high performing streets to carry on making the effort and the negative feedback encouraged those in low performing streets to join in with the food waste collection scheme.

The descriptive statistics in Table 2 show that the mean participation rate in the streets that were given feedback cards rose from 48.1 per cent before the first intervention to 49.1 per cent afterwards and then rose again to 50.1 percent after the second intervention. Among the control group streets the mean participation rate rose from 51.5 per cent to 52.0 per cent but then dropped to 50.7 per cent. When comparing first follow-up to baseline, recycling participation in the canvassed group rose by 1 per cent whilst the control group rose by 0.5 per cent, so overall, in the short term, the treatment group improved its recycling by 0.5 per cent in comparison to the control group. When comparing second follow-up to baseline, recycling participation in the canvassed group rose by 2.0 per cent and the control group fell by 0.8 per cent, so overall, after receiving two interventions the treatment group improved it's recycling by 2.8 per cent in comparison to the control group.

[Table 2 here]

Table 3 presents the differences between the mean food waste participation rate of the treatment and control groups across the whole time period. The difference of the first post intervention participation rate and base was small and not statistically significant ($p>0.1$). However the difference between treatment and control group means of the second post intervention and the first post intervention was 2.3% and is statistically significant. When we saw overall change of the outcome, i.e. the difference of the second post intervention rate and base rate, the difference of 2.8 per cent and is statistically significant ($p<0.01$). This indicates that the first feedback postcards had no significant impact on participation, but the cumulated effect of receiving two feedback cards was a 2.8% rise in the recycling participation rate.

[Table 3 here]

4.2 Regression Models

For our analysis, we used multilevel mixed-effects logistic regression that accommodates mixed-effects models for binary or binominal responses. Mixed models contain both fixed effects and random effects; fixed effects are parameters corresponding to an entire population or certain repeatable levels of experimental factors and random effects are parameters corresponding to individual experimental units drawn at random from a population. The fixed effects are analogous to standard regression coefficients and are estimated directly. On the other hand, random effects are not directly estimated, however can be calculated according to their estimated variances and covariances (Goldstein 1995). Random effects may take the form of either random intercepts or random coefficients. Fixed effects models that assumes all observations are independent of each other, are not appropriate for analysis of correlated data structures such as clustered and or longitudinal data. The grouping structure of the data may consist of multiple levels of nested groups or crossed over more than one groups. In our study, households are nested within streets, and also within neighbourhoods, but streets and neighbourhoods are crossed with each other. Some streets are very long across a few borders of neighbourhoods. The length of streets varies across areas; the shortest street consists of one household and the longest of 229 households. The longest street crosses from a very dense residential area to more sparsely populated residential area near to a school and cemetery. We expect that participation in the food waste recycling may be influenced by both streets and neighbourhoods. Thus our model incorporates both streets and neighbourhoods as sources of variation in participation, with households nested in the cross-classification of both streets and neighbourhoods.

We have data from 9,082 households that live on 318 streets and cover six waste collection areas. We have a response variable *participation rate*, which is measured at the household level. We have two explanatory variables at the household level: *treatment*, i.e. the

treatment group=1, the control group=0, and baseline participation rate (*baseline*), i.e. participated=1, not participated=0. We have a street level variable (*streetsize*). We have at the neighbourhood level two explanatory variables that indicate the level of deprivation (*deprivation*) and the proportion of single households (*single*).

At the household level, we can write an intercept-only model as:

$$Y_{i(jk)} = \beta_{0(jk)} + e_{i(jk)} \qquad (1)$$

Where the participation rate of household $Y_{i(jk)}$ of household *i* within the cross-classification of street *j* and neighborhood *k* is modeled by the intercept (the overall mean) $\beta_{0(jk)}$ and a residual error term $e_{i(jk)}$. The subscripts (*jk*) are written between parentheses to indicate that they are conceptually at the same level; the (*jk*)th street/neighbourhood combination in the cross-classification of streets and neighborhoods (Hox 2002). The intercepts (*jk*) indicate that presumably the intercept $\beta_{0(jk)}$ varies independently across both streets and neighbourhoods. Thus, we can model the intercept using the second level equation.

$$\beta_{0(jk)} = \gamma_{00} + u_{0j} + v_{0k} \qquad (2)$$

In equation (2) u_{0j} is the residual error term for the streets, and v_{0k} is the residual error term for the neighborhoods. After substitution, this produces the intercept-only model:

$$Y_{i(jk)} = \gamma_{00} + u_{0j} + v_{0k} + e_{i(jk)} \qquad (3)$$

Where the outcome variable is modelled with an overall intercept, together with a residual error term u_{0j} for street *j* and v_{0k} for neighborhood *k*, and the individual residual error term $e_{i(jk)}$ for household *i*, in the cross-classification of street *j* and neighborhood *k*.

[Table 4 around here]

The first model presents the results for the intercept-only model. Since cross-classified models usually contain more than two levels, which are not all squarely nested, the table does not use the usual sigma term for the variance components, rather names that correspond to the proper variable and level (Hox 2002). Thus, the term $\sigma^2_{\text{int/}street}$ to the term σ^2_{u0}. The term $\sigma^2_{\text{int/}neighborhood}$ corresponds to the term σ^2_{v0} for third levels intercept variance.

We can find out the intraclass correlation coefficient, which addresses the correlation of the observations within a cluster. Here each household is possibly clustered by street and/or areas. ICC describes how strongly households in the same group, i.e. street or area resemble each other. There are at least two ways to estimate ICC, however we follow the approach for the multilevel logistics (Snijders and Bosker 1999). As the logistic distribution for the level one residual implies a variance of $\pi^2/3 = 3.29$, the intraclass correlation for a two-level logistic random intercept model with an intercept variance of τ_0^2 is:

$$\rho = \frac{\tau_0^2}{\tau_0^2 + \pi^2/3}$$

Thus the intraclass correlation of the street level is 0.12/(0.12+3.29)= 0.118, and the intraclass correlation for the neighborhood level is 0.444/(0.12+3.29)=0.035. We calculate

that 12 per cent of the total variance is accounted for by the streets and 4 per cent by the neighborhoods.

The estimated coefficient for the intercept is the log odds of a household without treatment. In other words, the odds of participating in the scheme for the whole population are 0.076. When we convert into probability from the odds, exp (0.023)/ (1+exp (0.023)), the overall probability of participating in the scheme is 0.506. In other words, the average participation is 51.0 per cent without taking account of the treatment and other effects.

In Model 1 we introduce treatment, baseline and the interaction term of treatment and baseline as our explanatory individual level variables. The treatment had a positive effect on the participation rate. It means the treatment group after receiving feedback performed better than the control group at the significance level of 0.01. Also, those who participated at the baseline continued to participate in the scheme. The interaction of treatment and baseline rate attempts to describe how the effect of a predictor variable depends on the level or value of another predictor variable. In the presence of interaction term of treatment by baseline, we have actually two equations: one for the treatment group and one for the control group.

For the treatment group, the equation is:

$$\log(p/(1-p)) = \beta_0 + \beta_2 * baseline + \beta_4 * stsize$$

For the control group, the equation is：

$$\log(p/(1-p)) = (\beta_0 + \beta_1) + (\beta_2 + \beta_3) * baseline + (\beta_4 + \beta_5) * stsize$$

The coefficient for baseline rate is the effect of baseline for the control group. More explicitly, we can say that for the control group, participation at the baseline yields a change

in log odds of 2.772. On the other hand, for the treatment group, participation at the baseline rate yields a change in log odds of (2.772+ (-.235)) =2.537.

In terms of odds ratios, we can say that for the control group, the odds ratio is 15.911 (exp (2.772) =15.990). The odds ratio for the treatment group, for participation at baseline is 12.642 (exp (2.537) =12.642). The ratio of these two odds ratios (the treatment group over the control group) is the exponentiated coefficient, odds ratio for a one-unit increase in the covariate, for the interaction term of treatment by baseline: (12.642/15.990)=exp(-0.235)=.791). This means that the odds of the treatment group who were treated and had participated in at the baseline is 21 per cent lower than the odds of the control group. This result indicates that the feedback cards were not effective on those households who were already recycling their food waste at baseline: households who were participating in the scheme at the start were more likely to be still participating later if they were in the control group. Feedback worked best when given to people who were not currently recycling their food waste through the kerbside scheme.

Model 2 examines the interaction between treatment and street size to see whether the treatment is more effective on longer or shorter streets. There is a small but significant effect: the treatment was more effective on households on smaller streets and this effect diminished as street size gets longer. For the control group, one household increase in street size yields a change in log odds of 0.002. On the other hand, for the treatment group, one household increase in street yields a change in log odds of -0.002 (.002+(-0.004))= -0.002). In terms of odds ratios, we can say that for the control group, the odds ratio is 1.003 (exp(.0022)=1.002). The odds ratio for the treatment group, for one household increase in street is 0.998 (exp(-.001) =0.998). The ratio of these two odds ratios (the treatment group over the control group) is the exponentiated coefficient for the interaction term of treatment by street size: (.998/1.003==exp(-0.005)=0.996). This means that the odds of the treatment group to

participate in for one household increase per street is 0.4 per cent lower than the odds of the control group. Figure 1 shows that the probability of participation in the food waste scheme drops gradually up to the street size of 50 residents and then recovers slightly however swiftly decreases once the street size becomes over 100 residents per street.

Our final model 3 contains four interaction terms to test our hypotheses. The first interaction is treatment and base, which we considered in the earlier model. We continue to include it. We also leave in the interaction between treatment and street size to see whether the treatment is more effective on longer or shorter streets. We add interactions between treatment and different types of feedback (receiving smiley and smiley, frown and smiley, or frown and frown face on their feedback card) to see if these have differing effects on the outcome.

The reference group is the households which were on the smiley street first and then shift to be on the frown street after the first intervention. The result shows overall treatment effect disappears. On the other hand, the feedback treatment had a statistically significant effect upon among those households which were either on a smiley face street twice or on a frown face street twice. This indicates that the treatment impacted on only particular groups within the treatment group: feedback made the most positive impact on those who were either praised twice for their street's high performance or warned twice about their street's poor performance.

Households in collection areas with higher rates of deprivation were less likely to participate in the food waste collection, and this was statistically significant. The impact of living in an area with a high proportion of single person households was not statistically significant: households in those areas are no more or less likely to recycle their food waste than households in other areas.

5. Discussion

The study tested whether activating collective norms can promote environmental behaviour. To do this, we gave people feedback on how their participation compared to others. We argued this creates a sense of identity with the street and thereby encourages recycling. We expected that the treatment group would have a higher level of participation in the food waste scheme than the control group (H_1). We found that feedback did indeed have a positive impact on participation in the food waste scheme, and the effect size was 2.8%. Feedback is most effective if it is reiterated over time. There was no significant impact between baseline and T1: the first card had no significant effect and it was the cumulative effect of two feedback cards that had a significant impact on household participation in recycling food waste.

Secondly, we expected that the inclusion of the smiley and frown faces on the feedback would counter the boomerang effect, so the low performing streets would increase their participation (H_2) and the high performing streets would at least maintain their current levels of participation (H_3). As we saw in Fig. 1, there was a major shift from being a frown street to a smiley street in the treatment group. High performing streets which received the smiley face feedback were more likely than control streets to stay as high recycling streets; and low performing streets who received the frown face feedback were more likely that control streets to change to high performing streets. Model 3 of the regression (table 4) confirms that all feedback has a positive effect: feedback works equally well whether it is positive or negative. Feedback works well if it is delivering a consistent message: the effect was greatest on those households who received smiley feedback cards twice or frown feedback cards twice.

However, feedback cards were detrimental for one group of residents: households who were already participating in the scheme at baseline were more likely to stop recycling

after receiving a card than comparator households in the control group. We don't know for certain what is happening here, but we may speculate that this is because participating households on low performing streets are discouraged from recycling because they get a message that their neighbours are not making an effort.

Finally, if individuals feel solidarity at the street level we expected that it would prompt them to cooperate to improve their recycling compared to the area average, but this effect would diminish as the street becomes longer (H_4). We saw strong correlation effects of street level at 0.052 after controlling for other covariates, demonstrating that there is a street effect on recycling; living on the same street impacts on participation in the food waste scheme. The effect of treatment is stronger on a shorter street, and the effect diminishes as the street becomes longer. The interclass correlation for the area level was relatively weak compared to the street level, showing that the street a household lives on has more impact on household recycling behaviour than the area they inhabit.

As with any field experiment, there are issues of generalisability beyond the population of study. The study population was confined to one town in the UK, but it included households in a number of different parts of the town and we have no reason to believe that the population is likely to be very different from other towns in attitudes to food waster recycling.

5. Conclusion

This randomized controlled trial experiment tested whether activating the collective norm through feedback promotes recycling. The treatment worked regardless of whether households receive a positive or negative signal in the form of a smiley or frown face. The feedback was most effective if delivered as a consistent message: those who were

encouraged by receiving a smiley face card twice continued to participate in the scheme. Also, those who happened to be on the poor performing street – and who therefore received a frown card twice - started participating in the scheme. Our results are consistent with the street being a suitable reference group for the promotion of social norms; households identify with the behaviour of others on their street.

The provision of information on the level of pro-social behaviour of others in the neighbourhood can act as a magnet, with those who already exhibit the behaviour lowering their efforts to the mean, and those with low participation rising to the challenge. The purpose of the smiley and frown faces was to counteract this "boomerang effect" (Schultz, Jessica et al. 2007) by reminding everyone that there is an injunctive social norm they should be aiming for. Unlike a previous study of energy use (Schultz, Jessica et al. 2007), which found smiley and frown-face feedback to be successful on both high and low energy users, we found that feedback is successful in encouraging non-recyclers to join the food waste scheme, but it acted to discourage existing recyclers from taking part in the scheme.

Theory suggests that appeals to collectives norm could promote collective action and we tested it by giving people feed back on their street's food waste recycling rate compared to others. The effect of feedback diminished as the size of street becomes longer, suggesting that people can identify more with others in their street when the street is shorter, creating a smaller reference group and one in which people can easily observe the behaviour of others. Living on a smaller street perhaps triggers the sense of needing to conform to a collective norm in a way that longer streets do not.

Food waste recycling is relatively new in the United Kingdom, with only 100 schemes in operation at the time of our study. Councils and environmental campaigners are keen to encourage participation in food waste collection schemes because of the environmental consequences of sending food waste to landfill, the reduced costs of disposal

and the re-use of the waste as compost. Our study suggests that the provision of feedback on street level performance is one method that can encourage participation in the new schemes, alongside other mechanisms such as publicity and canvassing. Feedback is likely to work best if repeated more than once, on shorter streets and among households who are not currently using the scheme. Although feedback has a modest effect size of 2.8 per cent, policy-makers may find it cost effective. Financially constrained local councils may use feedback to reduce landfill and so help combat climate change.

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Tables and Figures

Table 1 Description of the Study Areas in Oldham

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Deprivation score	11	13	17	28	28	16
The proportion of Single Household (HH)	18%	20%	24%	28%	34%	24%

Table 2. Summary statistics of recycling participation rate by street

	Baseline	1st follow-up	2nd follow-up
Control group	51.5	52.0	50.7
Treatment group	48.1	49.1	50.1

Table 3. Pre-Post changes on recycling participation rate of streets by group

	d1(T1-base) Mean (St. Err.)	D2(T2-T1)	d3(T2-Base) Mean (St. Err.)
Control (n=4,073)	0.005 (0.007)	-0.013 (0.007)	-0.008 (0.007)
Treatment (n=5,009)	0.010 (0.006)	0.010 (0.006)	0.020 (0.007)
Difference	-0.005 (0.010)	-0.023 (0.009)	-0.028 (0.0)
Paired sample t-test on pre to post	t= -0.5145	t= -2.570**	t(96)= -2.850**

Note: Difference=mean (control of d1, d2 and d3)-mean (treatment of d1, d2 and d3)

+: p< 0.1, *: p<0.05, **: p<0.01

Table 4. Estimates of the recycling participation rate of streets

Model	Regression coefficients (standard errors) (β (SE))			
	M0:	M1: Household level variables-only	M2: Household plus street level variables	M3: Household, street level variables & area covariates
Intercept	0.023 (0.092)	-1.384** (0.113)	-1.371** (0.115)	-1.484** (0.183)
Treatment		0.251** (0.082)	0.395* (0.090)	0.110 (0.196)
Baseline		2.772** (0.059)	2.747** (0.056)	2.719** (0.073)
treatment*baseline		-0.235** (0.078)	-0.215* (0.076)	-0.164+ (0.102)
Streetsize			0.000 (0.001)	0.002** (0.001)
treatment*streetsize			-0.004** (0.001)	-0.004** (0.001)
Being the above average street twice (smiley-smiley)				0.438** (0.109)
frown-smiley				0.805** (0.132)
frown-frown				-0.029 (0.114)
treatment *smiley-smiley				0.335+ (0.190)
treatment*frown-smiley				0.040 (0.225)
treatment*frown-frown				0.315+ (0.196)
deprivation			-2.416** (0.939)	-1.920** (0.807)
Single			-0.051 (1.212)	0.460 (1.030)
Variance of area level residual errors ($\sigma^2_{\text{int/}neighborhood}$)	0.123	0.055	0.058	0.008
Variance of street level residual errors ($\sigma^2_{\text{int/}street}$)	0.444	0.233	0.178	0.182
Intraclass correlation at area level	0.036	0.016	0.017	0.003
Intraclass correlation at street level	0.118	0.066	0.051	0.052

+: p< 0.1*: p<0.05 **: p<0.01