How to get those recycling boxes out: a randomised controlled trial of a door-to-door recycling campaign[1]

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Abstract

This paper reports on a recent randomised controlled trial to investigate whether doorstep canvassing is an effective way to encourage kerbside recycling. Previous research has suggested that doorstep canvassing can successfully raise recycling participation rates by confronting negative attitudes, increasing understanding of the scheme and resolving structural obstacles (Shaw et al. 2007). Households on small streets tend to participate more in recycling (Harder et al. 2006). The aims of the research are firstly to test the effectiveness of a door-to-door recycling campaign using an RCT method and secondly, to examine the impact of peer effects on recycling behaviour, looking at how street size affects changes in household recycling behaviour.

The research has been done in partnership with EMERGE, a not-for-profit organisation which delivers a weekly kerbside recycling service. Recycling participation rates for 6580 households were measured by observing bin set out rates over a three week period. Half of the streets in the area were randomly assigned to receive an intervention to encourage recycling. All households on these streets were visited by canvassers who were trained to promote and encourage recycling. Half of the streets were placed in a control group and received no special attention. Recycling participation rates for all households were measured after the intervention to see if the intervention had been effective in raising participation rates.

How to get those recycling boxes out: a randomised controlled trial of a door-to-door recycling campaign

It is widely acknowledged that the actions of citizens are essential to implement policies for a better environment, largely through modifying their individual behaviours. Creating environmentally positive outcomes is a massive task for the twenty-first century, as the planet faces the challenge of dealing with climate change and disposing of the products of an increasingly consumerist society. It is possible that much of the change will happen on its own, through awareness of the problems, responses to market incentives, and information from government and other actors. But it is also likely that it will need interventions, which will involve some direct contact with the citizens. While some of these could be the result of demonstration projects or the recruiting of community champions, it is likely that some kind of face-to-face contact between an advocate and the citizens will have a strong effect. The state or the voluntary sector may recruit a body of activists to mobilise the citizens to behave differently, much in a similar way canvassing can get people to vote, for example (Green and Gerber 2008).

It is unlikely that such actions will transform citizens, but they can be a useful complement to other interventions. We expect a modest effect based on the communication of information in a face to face context, a degree of persuasion and taking an interest in the person. With some activities, such as change in car use or lagging, it is hard to imagine such a change taking place without a considerable effort in persuasion, but many behaviour changes require modest changes in lifestyle, with reminders and cues being effective at getting to activities

that individuals already do. Here kerbside recycling is such an activity, where households leave out recyclable waste for collection by the local authority.

This paper provides a robust test of an intervention designed to increase recycling. Previous interventions have been based on observational studies, which may not be able to observe the intervention because of the difficulty of controlling for all the unobserved factors which may have influenced the outcomes of the intervention group in the time period. Here we present a randomised controlled trial of a street based intervention in Manchester, which we regard is a robust test of the impact of a door-to-door recycling campaign.

Although the intervention impacts on individuals, the unit of randomisation is the street. When the state or voluntary bodies interact with individuals they need to select units or communities to deal with. Not only is this practical in terms of delivering the intervention economically, it is based on an assumption that people operate collectively, that there are collective aspects to the provision of public goods. Theories of collective action imply this is the case: that the members of a unit, such as a street, will tend to act in relationship to each other. If one person can see another's activity, they will encourage them to behave in a more community-based way. This paper uses the street-based nature of this intervention to explore the relations between individual action and actions carried out in a community context.

This paper first reviews the literature on interventions designed to improve kerbside recycling; it then sets out the research design, elaborates the approach to the analysis of statistics, reports the results of the intervention, carries out analysis of the individual and street effects, and then concludes with a discussion of the implications of the findings for recycling and mobilisation campaigns and policy.

Literature Review

The effectiveness of interventions to raise recycling

A number of studies have been conducted to test the effectiveness of different interventions to raise participation in kerbside recycling schemes, which tend to use conventional, mainly observational methods, comparing areas or household with or without the intervention. Some have applied alternative interventions to groups of households and compared the extent to which recycling activity improves. Bryce et al (1997) divided an area into clusters of 100 households and then randomly selected four of the clusters to each receive a different form of personal contact. Woodward et al (2004) identified a recycling round of 1000 properties and split it into two groups, one of which received a new recycling service and one of which was a control group. Lyas et al (2004) divided an area into four groups of 170 households, three of which received a different motivational leaflet and one acted as a control. It is not explicit in either article whether the allocation was randomized. Timlett et al (2008) identified three groups of households, each designed to contain households with a similar variety of socio-economic status and delivered a different type of personal contact to each.

All of these studies provide useful examples of how to successfully raise kerbside recycling rates. None of them can demonstrate the efficacy of the intervention in the manner of a randomised controlled trial: the establishment of two or more comparison groups that are similar in all respects; the random allocation of households to one or other group; one or more group receives an intervention, but otherwise all the groups are treated the same; observations are made of all members of the groups before and after the intervention. An exception within the recycling literature is a field experiment examining the impact on recycling behaviour of providing written feedback on individual and neighbourhood recycling behaviour. This randomised controlled trial took a population of 600 households, divided them into contiguous groups of 5-16 households to reduce the diffusion of treatments and then randomly assigned the groups to one of four treatments or a control of 120 households per group (Schultz 1998). Finally, other studies have monitored participation in kerbside recycling schemes and used the data to examined the impact of street effects on the participation of individual households (Harder et al. 2006; Shaw 2008; Tucker 1999) . These studies have not included any intervention or encouragement to recycle, but illuminate the unit of the street which is important for this study.

Interventions to raise participation

Promotional and educational campaigns can raise participation rates by ensuring people understand the scheme and motivating people to get involved. There are a number of potential approaches to encouraging recycling, which illustrate where

the intervention for this project fits in. They range in type, appealing to different kinds of motivation.

Education and persuasion. High visibility events and roadshows can be successful in building awareness (Read 1999), though such interventions are hard to evaluate. Face to face contact on the doorstep is more effective than simply providing literature (Bryce et al. 1997; Reams and Ray 1993). Doorstepping has not been found to be effective in increasing set out rate or reducing contamination in areas where recycling is already high (> 60% households) but it does raise the range of materials recycled (Timlett and Williams 2008). This is the approach adopted in the current research - there is no compulsion, there is the direct approach by a friendly and engaging team. Such kinds of intervention have increased participation in elections by about seven percent in the UK (John and Brannan 2008).

Social Influencers The use of existing recyclers as role models can encourage others to participate. Bryce et. al. (1997) dicuss the role of "block leaders" who can act as role models for their street, delivering persuasive messages and recycling materials to their neighbours. Making people aware that others like them are recycling may raise recycling rates by introducing a desire for social approval. This type of approach has not been tested in a large scale trial (Bryce et al. 1997 p.36).

Incentives. The provision of incentives to individual households has been shown to be successful. This appeals to people's financial interest, though the sums are low. They work particularly well in areas with low recycling participation rates, using vouchers of at least £1 to be spent in local shops, which might indicate an appeal to poor people on the basis of the search for income. But incentives work regardless of the affluence of the area (Harder et al. 2006). However, they work in the short term, but participation then recedes (Bryce et al. 1997; Timlett and Williams 2008) and it may be that incentives act to crowd out intrinsic motivation (Bryce et al. 1997).

Commitment approaches. Asking people to make a verbal pledge or commitment to recycle can work. Bryce et. al. (1997) found that asking for a commitment to recycle led to householders recycling more frequently when compared to simply providing information about the scheme. Reams and Ray's (1993) study of student housing found that pledges secured through personal contact led to higher recycling rates than pledges through indirect contact or providing information. It may be the personal contact that makes the difference here rather than the act of making a commitment (Bryce et al. 1997; Reams and Ray 1993).

Feedback cards left by collection crews to highlight boxes which contain contaminated material can be effective in reducing the amount of contamination and it is a cheap approach (Timlett and Williams 2008). The crews can also post cards reminding non-recyclers about the service (Timlett and Williams 2008). The organisation which is a partner for this study, EMERGE, asks its crews to

leave feedback cards in contaminated bins, i.e. those bins that have materials that cannot be used for recycling.

Norms. A few studies have tried to change recycling behaviour by activating personal or social norms. 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 et al. 2004). 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 can be more successful in raising the frequency of participation and the amount of material recycled (Schultz 1998). Both the frequency of participation and the amount of material recycled rose significantly when households were left doorhangers[2] telling them the amount of material collected from their house last week and this week. Similar levels of success were achieved with doorhangers telling households the average amount of material collected from householders and the percentage participating in recycling in their locality (c. 200 houses) last week and this week (Schultz 1998).

Promotional campaigns will be most successful if they address three different factors influencing recycling behaviour – attitudes, awareness/understanding and structural barriers. These factors will affect non-recyclers and recyclers differently (Shaw et al. 2007). Non-recyclers may have negative attitudes to recycling (e.g.

[2] Doorhangers are cards which can be hung on front doors. They are used for campaigning purposes in the US where leaflets cannot be posted in post boxes because they are reserved for official mail only.

associating rubbish with vermin) that can be addressed with information and education. They may be unaware of the scheme or not understand how to use it. There may be structural barriers such as unsuitable containers or lack of storage. All three factors can potentially be part of a promotional scheme to non-recyclers. By contrast, those who are already recyclers probably have pro-recycling attitudes and an awareness/understanding of the scheme and have no structural obstacles to participating. A campaign targeted at those who already recycle might focus instead on expanding the variety of goods they recycle and promoting bring-sites for items not included in the household collection (Shaw et al. 2007). Shaw et al (2007) advocate the use of participation data to identify non-recyclers, infrequent recyclers and frequent recyclers and then targeting promotional strategies accordingly.

Street Effects

The unit of the intervention needs to fit in with the actual spaces that people recycle in outside their household, which can be blocks, neighbourhood or streets. Streets are important units of analysis because they are reference groups for households, and the place where their behaviour may be observable by neighbours and where observation of the recycling boxes by each household may stimulate more recycling and help an intervention through peer effects. Of course, streets may be too big to serve this purpose with too many households which are split up by natural breaks within the street. Several studies evaluate this spatial scale.

Tucker (1999) examined the impact of street effects, using data from five newspaper recycling schemes in Northern England and Scotland. This was done by comparing set out rates, participation rates and set out weights for streets. They found that there is a normative influence - households are more likely to set out a recycling box if others in their street recycle regularly. But the streets with the highest set out rates do not have the highest set out weights and the proportion of very low weight set outs tends to be highest in the streets with high set out rates. The authors suggests that living on a street with high participation rates may encourage non- or infrequent recyclers to regularly recycle small amounts of material, rather then increasing the absolute amount of material recycled: 'Normative influences are thus likely to act on perceptions of weights worthwhile recycling as much as, or perhaps more than, reinforcing pro-recycling attitudes, or overcoming barriers against recycling' (Tucker 1999: 79).

Shaw (2008) monitored the recycling behaviour of 1700 households in a London borough. Contiguous blocks of households were identified by sectioning streets, taking account of road intersections, open spaces, non-domestic buildings etc. The observed recycling behaviour of households within these blocks was compared to a numerical model providing a benchmark of anticipated behaviour. In shorter contiguous blocks (less than 15 houses) householders were influenced by the recycling actions of their nearest next door neighbours. The influence was more marked in cul-de-sacs than in linear streets. The influence of neighbours diminished as the length of the blocks increased. This study considers only interactions with nearest immediate neighbours, not a wider street effect (Shaw 2008). Harder et al (2006) found that households on small roads tend to

participate more in recycling. Suggested factors include increased attachment to the neighbourhood, community spirit and peer pressure, but the reasons are not explored in depth and this is identified as a potential area for future research. None of these articles examines the impact that an intervention can have on street effects on recycling.

Research Design and Methods

The study site

We focused on one area within which to do the research, randomising streets within it. This is very common in mobilisation or canvassing campaigns because of the economics of a field force needed to cover an area, and in this case also needed because of the localised nature of recycling services. The advantage is that we control out large differences in background, but it makes inference from these studies local. Although there is no reason to believe the area we selected is particularly different from others of its type, or that we would observe very different effects in other cities in the UK, it has unique characteristics, which is a high number of ethnic minorities in one part of the area. This adds an extra interest to the study because it shows that community based campaigns may work in areas of diversity, and where it might be thought there would be a lack of engagement to externally imposed campaigns and language and cultural barriers to understanding them.

The research was conducted in two adjoining neighbourhoods, Old Trafford and Gorse Hill, which are within Trafford Metropolitan Borough Council (MBC), close to inner city Manchester. The housing is a mixture of Victorian terraced and more modern semi-detached houses. Flats and commercial properties were not included in the study because they are not eligible for the recycling service. Old Trafford is close to Manchester City Centre. It is an ethnically diverse area, with 67 per cent of its residents being from an ethnic minority. The largest single ethnic group is Asian or Asian British. It is a relatively deprived area: seven of the ten super output or neighbourhood areas in Old Trafford are within the lowest 20 per cent of all areas in England in terms of multiple indicators of deprivation and three areas are within the lowest 6 per cent. Most of the housing is traditional low rise properties, both terraced and semi-detached. Gorse Hill is further from the City Centre. It is less ethnically diverse, with 15 per cent of residents being from an ethnic minority. It is relatively deprived in national terms, but less deprived than Old Trafford: its super output areas are in the lowest 20-30 per cent of areas in England. Most of the housing is traditional semi-detached and terraced. Table 1 gives the background statistics.

Table 1. Neighbourhood Statistics for Old Trafford and Gorse Hill

		Old Trafford	Gorse Hill
Ethnicity (2001 census)	White	53%	85%
	Asian/Asian British	28%	4%
	Black/Black British	13%	6%
	Mixed	4%	4%
	Chinese & other	2%	1%

Index of Multiple Deprivation (2007)		3 SOAs: lowest 6% 4 SOAs: lowest 20% 3 SOAs: lowest 30% of all areas in England	All 3 SOAs are in the lowest 20-30% of all areas in England
Housing type (ONS 2004)	Detached Semi-detached Terraced Flats and other	4% 42% 38% 16%	3% 44% 45% 8%
All data sourced from ONS http://www.neighbourhood.statistics.gov.uk accessed 17/09/08			

Recycling facilities in Trafford

Kerbside recycling is provided by EMERGE, a not for profit organization which is commissioned by Trafford council to provide a weekly recycling service to all 6580 households. Research shows that the design of a recycling service has an impact on participation, in particular the inclusion of a wide range of materials encourages participation (Harder et al. 2006; Woodward et al. 2005). The scheme in this study takes a very broad variety including glass, foil and cans, thin card, textiles and shoes, paper, plastic bottles and household batteries. Offering appropriate containers promotes recycling (Woodward et al. 2005). The scheme in this study offers a box (for glass bottles, cans, thin card, directories and textiles) with three separate bags for paper, plastic bottles and batteries. The area covered is a mix of terraced housing and semi-detached housing. The boxes are probably easier for the terraced households, where wheeled bins are problematic because of storage and access issues, but they may be less convenient for houses with

gardens. Frequency of collection and day of collection has an impact, helping encourage a routine or habit of recycling behaviour. Some recycling organisations alternate collections of recyclable and residual waste, with each being collected fortnightly on the same day in alternate weeks. This can work successfully (Wilson and Williams 2007) and challenges the public's perception that recycling is an add-on rather than a core feature of the waste system, but it can be controversial to end weekly residual collections (Woodward et al. 2005). In the EMERGE scheme, households have a weekly recycling collection. There is currently no co-ordination with the council's residual waste collection, so some households may have collections on two different days each week.

Vehicles collecting recycling waste should be visibly different from residual waste collection vehicles, so the public are clear that their recyclables will not end up in landfill sites (Woodward et al. 2005). The vehicle used in the EMERGE scheme is distinct and materials are sorted as they are placed in the van, giving a clear message that the service is trustworthy. Education and promotion are important in encouraging recycling (Harder et al. 2006; Read 1999; Woodward et al. 2005). The local council contacts residents four times a year to promote the service. If households leave out contaminated boxes (including non-recyclable waste or placing waste in the wrong containers), they are left with a card explaining how the service works. In short, the service did not provide great obstacles to increasing recycling.

Experimental Design

Old Trafford and Gorse Hill has 6,580 households in 194 streets. Each street was randomly assigned to either the intervention group or the control group. The randomisation was done by street rather than at the individual household level because of the expectation that household recycling behaviour is influenced by other households in the street: households are more likely to recycle if they see that others in their street are doing the same and they may be influenced by social norms that emerge over recycling. The data was handed over to the York Trials Unit for randomisation, using the SPSS random sampling function, to an intervention and control group of equal size. The data was stratified by district (Old Trafford or Gorse Hill) and street length prior to randomisation.[3] The treatment group contained 3,468 households in 97 streets and the control group contained 3,112 households in 97 streets. In association with the Randomised Controlled Trials unit at the University of York, we calculated the likely effect size needed and power of our experiment, which was based on an estimate of the correlations between the pre and post recycling rate of .8 and on the ICC figure of .3, based on a small sample of existing data, which we had from EMERGE. With acceptable power at 80 per cent, we calculated that the effect size needed would be eleven per cent, but would be likely to be higher if the upper end of the calculations of the ICC and pre and post correlations were adopted.

[3]. We thank Professor David Torgerson of the York Trials Unit, Department of Health Sciences, University of York, who executed the randomisation

Measurement

We needed a unit of measurement that would be valid, reliable and meet the needs of a RCT. There are three potential approaches to measuring kerbside recycling activity. Firstly, questionnaires asking people to self-report their recycling activity are sometimes used, but they tend to be unreliable, over-reporting the extent of recycling activity (Shaw et al. 2007; Timlett and Williams 2008). Secondly, observations can be made of which households have put out a recycling container for collection: this typically takes place shortly in advance of the recycling collection. The simplest measure is set out rate, the proportion of households placing material out for collection on any given occasion:

$$\text{Set out rate} = \frac{\text{No. of households placing material out for collection}}{\text{Total no. of households}} \times 100$$

Some households may not recycle weekly because of holidays and having low levels of recyclable waste. So, studies often also calculate participation ratios, the proportion of households placing material out for collection at least once in any given period. Published studies tend to have adopted government (DETR) guidance issued in 1999 which recommends observations over four weeks (Harder et al. 2006; Shaw et al. 2007; Tucker 1999; Walsh and Thomas 2004; Woodward et al. 2005). The most recent guidance from the Waste and Resources Action Programme (WRAP), supported by the environment department, Defra, recommends monitoring over three weeks (WRAP 2006). This more recent guidance is not yet widely reflected in the academic literature, but it is the current

best practice and was adopted in this research. It has been adopted in one recent study (Timlett and Williams 2008).

$$\text{Participation ratio} = \frac{\text{No. of households placing material out for collection at least once in 3 weeks}}{\text{Total no. of households}} \times 100$$

Some bin observation schemes go a step further and examine bin contents to see the time span of newspapers put out by households (Tucker 1999) or the variation of materials placed in the bin, seeing whether the full range of recyclable materials has been included or whether there is any contamination (Lyas et al. 2004; Schultz 1998) but we did not think this was necessary for this experiment. Nor did we opt for a third type of measurement, weighing recycled materials, either per household, using a spring balance (Bryce et al. 1997; Tucker 1999), by comparing the total weight of recyclable materials collected in trial and control areas (Woodward et al. 2005) or comparing the average weekly tonnage before and after a recycling campaign (Read 1999).[4]

Participation ratios and weight measure different aspects of recycling and there is not necessarily a correlation between them. A high participation ratio simply indicates that a high proportion of households place their bin out for collection,

[4] Weighing at the household can be problematic and is subject to weather variation (W. J. Bryce, R. Day, and T. J. Olney, 'Commitment Approach to Motivating Community Recycling: New Zealand Curbside Trial', *The Journal of Consumer Affairs,* 31/1 (1997), 27-52.). An alternative is to estimate the amount of recycling per household by counting the number of bags set out (J. K. Lyas, P. J. Shaw, and M. Van Vugt, 'Provision of Feedback to Promote Householders' Use of a Kerbside Recycling Scheme - a Social Dilemma Perspective', *Journal of Solid Waste Technology,* 30 (2004), 7-18.) or recording how full recycling boxes appear to be (P. W. Schultz, 'Changing Behavior with Normative Feedback Interventions: A Field Experiment on Curbside Recycling', *Basic and Applied Psychology,* 21/1 (1998), 25-36. Comparing the weight of material collected from trial and control groups will not be possible in this experiment because households on the same collection round will be randomly allocated to different intervention groups.

but does not measure how full the bins are. A high participation rate does not necessarily equal a high recycling rate (Woodward et al. 2005).

The participation ratio and set out rate can be used together to identify households as frequent recyclers, infrequent recyclers or non-recyclers (Harder et al. 2006; Shaw et al. 2007). For example, households who set out on two or three occasions over three weeks can be classified as frequent recyclers; those who set out on one occasion as infrequent recyclers and those who do not set out over the three week period as non recyclers. There may also be an additional category of non-kerbside recyclers who choose to use bring sites (Shaw et al. 2007), who will not be picked up by participation monitoring.

Where the impact of an intervention is being studied, measurement is usually done shortly before the intervention and then repeated immediately afterwards (Read 1999). But there is often an increase in recycling in response to an intervention and then a drop off in participation as time passes. Repeating the measurement a third time a few months later can take account of this "recycling decay" (Woodward et al. 2005).

Treatment

All households on the 97 streets in the intervention group were visited by a team of canvassers. The four canvassers were specifically recruited and trained for the task. The canvassers received one day's training on the EMERGE recycling service, the benefits of recycling, possible arguments against recycling, canvassing

issues and practical issues relating to health and safety. The canvassing took place over a period of six weeks between 3pm and 7pm Monday to Friday and 11am – 3pm on Saturday. These times were chosen to maximise the number of contacts, based on previous best practice (WRAP 2006). The contact rate was continually measured during the period of canvassing to assess whether the timing of the visits was appropriate to maximise the number of successful visits. These times were found to be the most effective. The lowest contact rate was on Saturdays, but Saturday visits were not discontinued because of an assumption that the people who were at home on Saturdays may not be available at other times. After all 97 streets had been canvassed once, a repeat canvass of the whole area was done, calling at all the households who had not been contacted on the first occasion. These second visits were arranged at a different time of day from the first visit to maximise contact. During the first canvass 40 per cent of households were spoken to. By the end of the second canvass, 61 per cent of households had been contacted, 2,129 of the 3,468 households in the intervention group. The rate of contact compares favourably with other canvassing projects (WRAP 2006).

The canvassing focussed on three factors which influence recycling behaviour: awareness, attitudes and structural barriers (Shaw et al. 2007). Canvassers made sure householders were aware of the service by confirming the day and time of collection, explaining the variety of materials that can be recycled. They promoted positive attitudes to recycling and were enthusiastic about encouraging people to take part. They addressed barriers to recycling by providing any plastic bags as required and ordering new boxes if they were lost or missing. They dealt with any problems or queries about the service or passed any difficult queries onto

an EMERGE manager. The canvassers were encouraged to be enthusiastic and conversational on the doorstep. They were provided with scripts to use as prompts [Appendix 1] but were encouraged to adapt them to their own conversational style.

Canvassers were asked to take a different approach dependent on whether the household were currently recyclers or non-recyclers. Existing recyclers were thanked for using the recycling box, reminded of the variety of recyclable materials and – if they seemed enthusiastic - asked if they would like to become recycling champions. Non-recyclers were encouraged to recycle, informed of the day and date of collection and materials collected. They were then asked if they could be counted on to recycle regularly. Both groups were asked if they had any questions or concerns about the service and if they needed replacement receptacles. An information leaflet was given to every household canvassed and was also delivered to houses where no one was at home. The leaflet described what materials could be recycled, outlined the service provided, gave details of the time and day of collection and provided contact details for more information.

A log sheet was produced for each street. It listed every household on the street, with an indication of whether they currently recycle or not. Canvassers entered the date and times that the street was canvassed. The information was used to monitor when the best times to canvass were and to ensure a different time for follow up visits. Canvassers completed the sheets to show which houses had been canvassed and whether additional bags had been provided and new box requests

were entered. About 500 new boxes were requested. There was space to note if there was no one in the household who spoke English well enough for the canvassing to take place. The intention had been to re-visit these households with a translator, but the number of cases was lower than anticipated (29 households) and the number of languages was very varied, so the re-visits were not undertaken. Volunteer recycling champions were noted on the sheet and contacted by EMERGE at a later date. We found that 29 people had volunteered.

Participation Monitoring

Participation in the recycling scheme was measured for all households in the intervention and control groups. Participation has been measured at two time points: in March/April 2008 prior to the canvassing and in July 2008 after its completion. Monitoring was not done at bank holidays (because services were disrupted) or during school holidays (when some households might be away). Participation will be measured again in October 2008 to test the longer term effect of canvassing. The two sets of monitoring were done by two people not involved in any other aspect of the project, who were unaware which streets were in the treatment and control groups.

The monitoring was done on the same day as the waste collection. The monitor sat in the recycling vehicle while the crew were working and noted all the houses on the street that had placed recycling material outside the house boundary. The observations were noted down and then entered into an excel spreadsheet. The

monitoring was repeated over three consecutive weeks. Any household who recycled at least once on the three week period is counted as a recycler (WRAP 2006).

Data

The data is a data set with a total sample of 6,580 households in 194 streets. The average street size is 33.9 properties. Table 2 divides the sample into the two groups: the control and the intervention groups. Ninety-seven streets were randomly allocated to each of the groups. In the control group, there are 3,112 properties whilst in the intervention group there are 3,468 properties.

Table 2. Sample distribution by group

Groups	Households	Streets	Average street size
Control	3112 (47%)	97 (50%)	32.1
Intervention	3468 (53%)	97 (50%)	35.7
Total	6580 (100%)	194 (100%)	33.9

The main outcome variable is the records of actual recycling behaviour in terms of participation rate for periods of pre- and post-intervention. A variable of the change in the means of participation rate between the pre- and post-intervention periods is derived. There are also a number of explanatory/independent variables based on the intervention and literature. This current paper examines three explanatory variables: Group (coded 0=Control Group, 1=Intervention Group),

District (coded 0=Old Trafford, 1=Gorse Hill), Street size (total number of households on the street). The data also has two treatment related variables we have not used at this stage of reporting: Canvass rate (coded 0=Not canvassed, 1=Canvassed); Recycle box (coded 0=Box not requested/provided, 1=Box requested and provided).

Analyses/Models

First, we undertook analysis to test whether the difference in the change of the means of recycling participation rate between the control and intervention group is significantly different from each other and from zero over pre- and post-intervention periods. The null hypothesis is that there is no significant difference in the change of the means of participation rate between the control group and the intervention group over pre- and post-intervention periods. A standard analysis for this purpose would be the independent samples t-test as it would be appropriate for data like this one where there are outcome interval measures at two time points for each of the two groups (intervention and control).

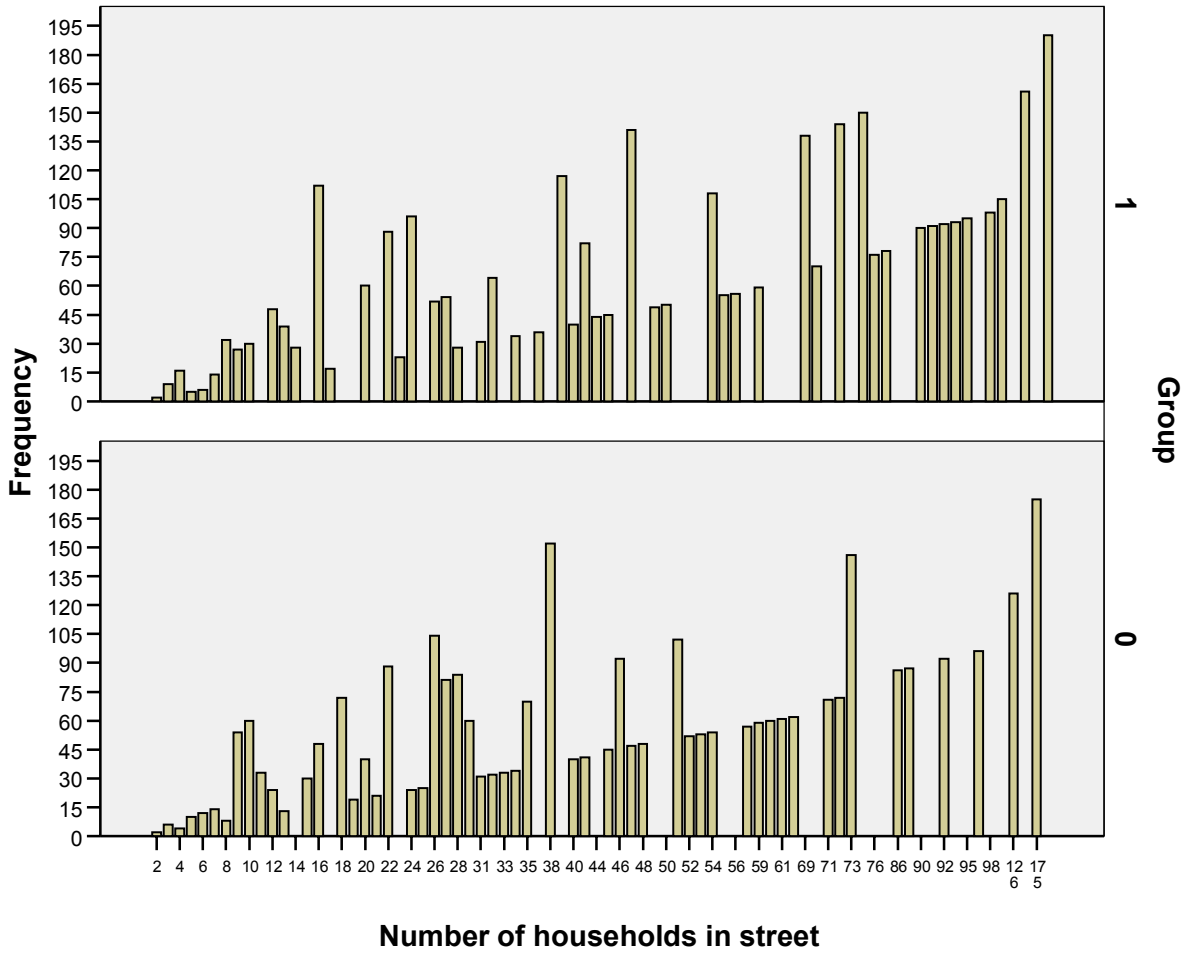
However, this data has a sample of 6,580 individual households nested in 194 streets and therefore a standard independent samples t-test to compare the change in the means of participation rate does not take into account the clustering or grouping effect (in our sample the street effect). The clustering effect is measured by the intraclass correlation coefficient (ICC) (UCLA 2008). The rationale behind it is that with grouped data observations, i.e. households in our sample from the same street are generally more similar than the households from different streets.

This violates the assumption of independence of all observations (Hox 2002:14). ICC is a measure of the correlation of the households within a cluster (street), in other words, the amount of dependence or grouping effect.

To take the clustering data structure into account, we could run the independent samples t-test using summary statistics. However, as shown on Figure 1 the streets are of different sizes but the independent samples t-test using summary statistics gives them all equal weight. But the analysis should take into account the variation in street size as well as the clustering of the data. There are two methods to conducting such an analysis. One is to weight the t-test and the other is to use the individual households as the unit of analysis but to adjust the standard errors for the clustering using robust standard or Huber-White standard errors (Raudenbush and Bryk 2001). The estimates of both methods are identical and the standard errors, p-values and 95% confidence intervals are only very slightly different (Miles 2008).

Figure 1. Number of households in street by group

(Group 1 = Intervention, Group 0 = Control)

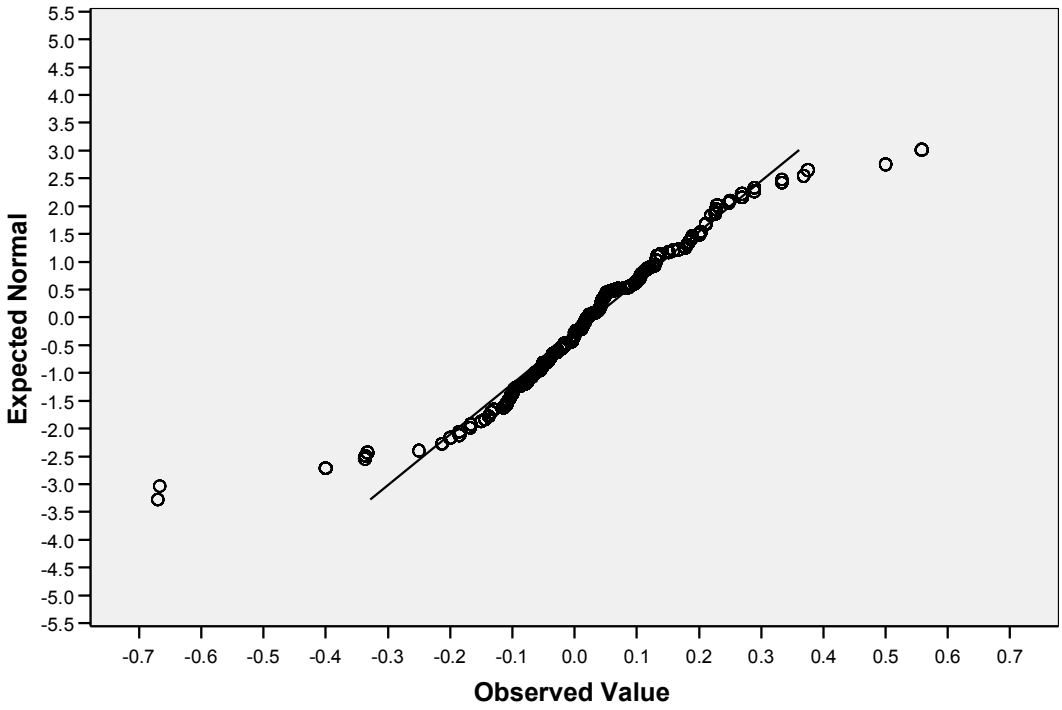


Next, we conducted the regression analysis using robust standard errors to examine how the outcome variable (i.e. the change in the means of participation rate) is predicted by the three explanatory variables of group, district and street size. This regression analysis also takes into account both the variation in street size and the clustered data structure.

Figure 2 is a normal Q-Q Plot to compare the distribution of the outcome variable (i.e. the change in the means of recycling participation rate) to the normal

distribution. The straight line represents what our data would look like if it were perfectly normally distributed. Our actual data is represented by the circles plotted along this line. The closer the circles are to the line, the more normally distributed the data looks. Here, most of the points fall along the line. This is a good indicator that our data is normally distributed. In addition to the graphical examination of the distribution of the data, we have also done the Kolmogorov-Smirnov test (Chakravarti et al. 1967) and the Shapiro-Wilk test (Shapiro and Wilk 1965). Both tests consider whether the samples are drawn from a normal distribution. The Kolmogorov-Smirnov D statistic for this data is 0.099, p=0.000 whist the Shapiro-Wilk W statistic is 0.954, p=0.000. These normality test statistics confirm that the data is normally distributed and therefore is suitable for Normal theory analyses.

Figure 2. Normal Q-Q Plot of change in the means of recycling participation rate



Unlike the multilevel regression analysis where the estimation technique Maximum Likelihood (ML) is used, the usual estimators in the Huber-White standard errors method are Ordinary Least Squares (OLS) estimators (see Hox

2002; Muthén and Muthén 2007; Snijders and Bosker 2003 for relevant discussion on OLS and ML).[5]

Results

The weighted t-test using regression

To carry out a t test with weights we use regression, which yields the same results as a standard t test of the difference between group means (except for the change in sign) and the *p* value is the same. The results of the regression using summary statistics presented in Table 3 indicate that we can reject the null hypothesis. There is a significant difference in the change of means of participation rate between the control group and the intervention group over pre- and post-intervention periods. The intervention group increased their recycling participation rate by 6.7 per cent after the intervention ($53.4_{post} - 46.7_{pre}$), whilst the control group reduced participation rate by 1.0% ($53.1_{post} - 54.1_{pre}$) from pre-intervention to post-intervention. This results in the intervention group having a difference in the change of means of recycling participation rate from pre-intervention to post-intervention by 7.7% (coefficient(β) of Group is 0.077 with standard error of 0.015) greater than the control group over the same period and this difference is statistically significant (t=5.22, p <0.000 (two-tailed)).

[5]. This paper runs all its regression models in Stata.

Table 3. The difference of recycling during the intervention (weighted)

	β (SE)	t	p	95% CI	
				Lower	Upper
Group (intervention/control)	0.077 (0.015)	5.220	0.000	0.048	0.106
Intercept (cons)	-0.010 (0.011)	-0.930	0.354	-0.031	0.011

The regression model

Table 4 presents the results of the regression analysis using robust standard errors method to examine how the outcome variable (i.e. the change in the means of participation rate) is predicted by the three explanatory variables group, district and street size. The regression coefficients (β) for both group and district are statistically significant. The regression coefficient for group is 0.072 (note that this figure is similar to group coefficient in the weighted t-test presented in Table 3). Since group is coded 0=Control Group, 1=Intervention Group and the recycling participation rate is in percentage term, this means that on average the households in the intervention group had a recycling participation rate 7.2 per cent higher than those in the control group, which shows the greater efficiency generated for the estimate of the treatment effect. The regression coefficient (β) for district is -0.049 and district is coded 0=Old Trafford, 1=Gorse Hill. This means that on average the households in Gorse Hill had a recycling participation rate 4.9 per cent lower than those in Old Trafford. The coefficient for Street Size is not significant which means that this variable is not a strong predictor for the recycling outcome variable.

Table 4. Regression with explanatory variables group, district and street Size

	β (SE)	t	p	95% CI	
				Lower	Upper
Group (intervention/control)	0.072 (0.013)	5.420	0.000	0.046	0.098
District (Old Trafford/Gorse Hill)	-0.049 (0.014)	-3.610	0.000	-0.076	-0.022
Street Size	0.000 (0.000)	1.780	0.077	0.000	0.001
Intercept (cons)	-0.007 (0.017)	-0.450	0.657	-0.040	0.025

The ICC and design effect

We can obtain the intraclass correlation coefficient (ICC) by running a long one-way analysis of variance. The results are presented in Table 5. The ICC is equal to 0.017. Thus 1.7 per cent of the variance of the recycling participation rate is at the street level, which means that the street effect in relation to people's recycling is weak in this sample.

Table 5. The intraclass correlation coefficient (ICC)

Source	SS	df	MS	F	p	ICC	95% CI	
							Lower	Upper
Between street	78.582	193	0.407	1.580	0.000	0.017	0.007	0.026
Within street	1649.217	6386	0.258					

SS: square sum

df: degree of freedom

MS: mean square

The design effect for constant cluster size is calculated by:

$$\text{Design effect} = 1 + (m - 1)ICC$$

where m is the cluster size . We have varying cluster size so we replace m by

$$\text{Sum } m_i^2 / \text{Sum } m_i = \text{Mean } m_i + (\kappa - 1)\text{Var}(m_i) / (\kappa \text{ Mean } m_i)$$

where κ is the number of clusters. We can obtain the mean and variance of m_i from the summary data which are as follows:

$$m = 33.92 + (194 - 1)*31.09\text{^}2/(194*33.92) = 62.27$$

Then we use ICC = 0.017 to calculate the design effect:

$$\text{Design effect} = 1 + (62.27-1)*0.017 = 2.04$$

The ICC and design effect tell us that this cluster-randomised trial has a relatively small cluster effect, as measured by the ICC=0.017. This produces a moderate design effect as the clusters are fairly large (194 streets). In turn, this leads to the conclusion that we may ignore the clustering.

Discussion and conclusion

The results of the experiment show that a door-to-door campaign can raise recycling by between seven to eight per cent points. This is in an area where the recycling service is good, and where there are terraced and semi-detached houses which are easy to canvass, so inference to outside the sample area needs to be made with caution. But such results are consistent with existing observational studies (WRAP 2006) and with the effects of door-to-door canvassing for other

contexts. The randomised controlled trial is a robust test of the intervention . In the absence of confounds to the experiment – we were not aware of any - we can assume that the canvassing worked.

The costs of carrying out the canvassing were £5605.59. This included the wages for four canvassers, additional wages paid to an EMERGE manager to supervise the team out of office hours, refreshments for the training day and the cost of calls made on the team's mobile phone. Other additional costs incurred during the project include the additional recycling bags and boxes and the safety jackets provided to the team, but these are part of the usual spending of EMERGE and so have not been included. The costs of the participation monitoring and other research costs have not been included. The canvassing resulted in 233 additional households from the intervention group recycling. The cost per additional household is £24.06.

The positive results may appear to justify the street-based nature of the intervention, which may be justified because of the ease of randomising streets and canvassing them. However, we present no comparison of efficiency with a campaign based on randomising individual properties or street blocks or neighbourhoods. In fact, our regression models show that even though the treatment effect is through the street, the explanation of the variance is through the individual level effects, by a large amount. The implication is that neighbourhood effect may be weak, but we need to explore those effects through interactions between the treatment and the various spatial scales we have.

Moreover, we need to evaluate the impact of social demographic factors, such as ethnic group in future analysis.

APPENDIX 1

CANVASSING SCRIPT

RECYCLERS

"Hello, I am calling on behalf of EMERGE recycling. We are visiting people in this area today to promote our recycling service.

I see from our records that you already use the recycling box. Thank you. By recycling we can all do our bit to save natural resources and reduce the amount of waste going to landfill.

Can I check that you know about all the materials you can recycle? They are shown on this leaflet:

Glass, Metal, Thin card	- Black box
Paper	- thick green sack
Plastic bottles	- thin green bag
Batteries	- small battery bag
Textiles	- separate carrier bag

Do you have all the receptacles you need to recycle?

Do you have any questions or concerns about the service?

Emerge is looking for keen recyclers like you to spread the word about recycling and report any problems with the service. Would you like to find out more about becoming a recycling champion?

Thanks for your support. I hope I can count on you to keep on recycling regularly."

CANVASSING SCRIPT

NON-RECYCLERS

NB: Our records are not perfect so do not challenge people if they tell you they do already recycle.

"Hello, I am calling on behalf of EMERGE recycling. We are visiting people in this area today to promote our recycling service.

By recycling we can all do our bit to save natural resources and reduce the amount of waste going to landfill.

Emerge collects from your street on _____ [day]. The collection is between 8.30 am and 4 pm, so it may be best to put it out the night before.

The materials you can recycle are shown on this leaflet:

Glass, Metal, Thin card	- Black box
Paper	- thick green sack
Plastic bottles	- thin green bag
Batteries	- small battery bag
Textiles	- separate carrier bag

Do you have all the receptacles you need to recycle?

Do you have any questions or concerns about the service?

Thanks for your time. Can I can count on you to recycle regularly in the future?"

If No; try to address any questions or concerns

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