Temporal displacement of environmental crime

Vollaard, Ben

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Salience of Law Enforcement: A Field Experiment*

Robert Dur† and Ben Vollaard‡

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Abstract

We conduct a field experiment to examine whether the deterrent effect of law enforcement depends on the salience of law enforcement activity. Our focus is on illegal disposal of household garbage in residential areas. At a random subset of 56 locations in a mid-sized city, law enforcement officers supplemented their regular enforcement activities by the practice of putting brightly-colored warning labels on illegally disposed garbage bags. This treatment made the existing enforcement activities suddenly much more apparent to residents. We find evidence for a substantial reduction in illegal disposal of garbage in response to the treatment.

JEL-codes: C93, K42.

Keywords: law enforcement, deterrence, perception, salience, disorder.

† Department of Economics, Erasmus University Rotterdam, Tinbergen Institute, CESifo, IZA. E-mail: dur@ese.eur.nl.

‡ Tilburg University, CentER. Email: b.a.vollaard@tilburguniversity.edu

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1. Introduction

Governments around the world spend substantial resources on law enforcement in an attempt to reduce crime. While the success of such policies is sometimes debated in the popular media, scholars in criminology and economics have by now built up a substantial body of evidence showing that police commonly drives down crime, even though the size of the effect depends on the exact context and the way resources are deployed (Durlauf and Nagin 2011, Nagin 2013, Nagin 2016, Chalfin and McCrary 2017). The evidence also suggests that deterrence tends to be the primary mechanism responsible for the crime-reducing effect (Draca and Machin 2015).

A critical factor determining the size of the deterrent effect of law enforcement is its salience among potential offenders. Salience refers here to the awareness of the chance of getting caught and the subsequent consequences, and as such is an essential mediator of deterrence. It has been shown that potential offenders are not always fully aware of the parameters of law enforcement. Instead, they develop beliefs based on experiences and observations, with personal experiences of what does and does not happen after they commit an illegal act being a major determinant of those beliefs (Sah 1991, Lochner 2007, Hjalmarsson 2009, Rincke and Traxler 2011, Anwar and Loughran 2011, Loughran et al. 2014). Learning about law enforcement based on personal experiences is likely to be slow, however. Generally, the chance of getting caught is low. Consequently, chances are that beliefs about the expected punishment – the product of the chance of getting caught and the punishment – rarely move upward. If potential offenders tend to underestimate the expected punishment in the absence of recent experiences, then they may engage in illegal acts that they would have refrained from if the punishment had been correctly anticipated. Underestimation of the expected punishment may result from being ill-informed, but also from heavily discounting events that have not occurred recently. Moreover, beliefs may be correct, but need not be part of active knowledge. As argued in Bordalo et al. (2013), not all that is known is part of active knowledge, since people cannot attend to everything at once.

In situations like these, greater deterrence might be produced by increasing people's salience of law enforcement deployment, as suggested by Jolls, Sunstein, and Thaler (1998). They provide an appealing example in the context of parking fines. The practice of putting small, plain parking

tickets under the windshield wiper could be replaced by a policy of sticking large, brightly-colored tickets that read 'violation' in large letters. The cost of doing so are minimal, but the existing enforcement activities suddenly become much more apparent to all those passing by. As a result, potential offenders may be more likely to be deterred.

Our paper is the first to put this idea to the test. We conducted a natural field experiment in which we increased the salience of law enforcement at a random subset of 56 locations for a period of five weeks and observed the behavioral response in terms of the number of violations. We also examine displacement of violations.

The experiment took place in the city of Heerlen, the Netherlands. We study a type of disorderly behavior that is known to be a major irritant in residential areas: illegal disposal of household garbage.[1] Given the public outcry and the empirical evidence that a disorderly environment may drive further degradation of the neighborhood (Cialdini et al. 1990, Keizer et al. 2008, Dur and Vollaard 2015, Keuschnigg and Wolbring 2015), local authorities often put a lot of effort in keeping the streets clean. In the city of Heerlen, service workers clean all garbage disposal locations scattered around the city several times per week. Moreover, two full-time officers have the sole task to detect and fine offending households at the 56 supposedly messiest locations in the city. These locations include locations with shared garbage bag disposal containers close to homes as well as locations with glass and paper disposal containers at thoroughfares and on squares. The latter type of container has a small opening for bottles or paper and is free to use. Garbage bag disposal containers have a larger opening, but only operate after inserting a card that is exclusively issued to nearby households, with each recorded use costing one euro. The fee of one euro is meant to provide an incentive for households to reduce waste.

In violation with the rules, residents regularly dump garbage bags and all kinds of discarded household items next to both types of containers, creating a mess.[2] The two full-time officers make

[1] Together with speeding and dog feces, littering – which includes illegal disposal of garbage – is reported to be one the three major nuisance crimes in the Netherlands Crime and Disorder Survey (Statistics Netherlands 2014).

[2] When residents want to dispose large items that do not fit into the garbage container, they are supposed to call for pick-up by city workers at their home address or to bring those items to one of the local garbage depots themselves.

a daily round along the supposedly messiest locations, and search for name and address identifiers in illegally disposed garbage. At the start of our experiment, this intensive enforcement policy had been in place for almost one and a half years. Even though the fine is 90 euro and the chance of being detected is about 5 percent on average, the problem persisted. The muted response to a relatively high expected penalty of 4.50 euro (0.05 times 90 euro) for a rule violation with presumably small benefits (avoiding the fee of 1.00 euro and a bit of effort) provided an ideal setting for an experiment aimed at increasing the salience of existing law enforcement activity.

In the treatment condition, the officers made their activities more salient by marking illegally disposed garbage bags with bright orange labels saying that the item was found by law enforcement and punishable to a fine of 90 euros. The warning labels were visible until the next cleaning of the area around the underground container by the Department of Sanitation, which commonly took place after a couple of hours to one or two days later. A benefit of our setting is that the officers follow a fixed routine: their deployment is independent from the level or trend of illegal disposal at container locations.

Our results are as follows. The estimated average treatment effect is a reduction in illegal garbage disposal by about 30 percent, but the effect is only marginally statistically significant. Further exploration of the data show that the effect is stronger and more precisely estimated during weeks with a relatively high treatment intensity and at container locations that were relatively clean in the baseline period. We also find that the effect is much larger (a reduction of 50 percent) and statistically significant at locations with garbage bag disposal containers, while a treatment effect is small and statistically insignificant at locations with glass and paper disposal containers. We find some evidence for displacement of illegal disposal. The latter finding should be no surprise since the warning labels also partly reveal which locations are surveilled and which locations are not surveilled.

Our paper contributes to the literature on deterrence. We provide evidence that the size of the deterrent effect is dependent on the salience of law enforcement activity. This finding provides an explanation for the persistence of forms of crime that do not seem to pay, such as bank robberies in the UK (Reilly, Rickman and Witt 2012; see also Wilson and Abrahamse 1998). Offenders may simply be overly optimistic about the expected return to crime if the upside is salient. The opposite

should then also be true: when the downside is salient, we should not observe crime that does seem to pay. Our paper also provides an explanation for the mixed evidence of the effect of punishment on offending: not all shocks in punishment that were studied may be equally salient (see Lee and McCrary 2017 and Hinnerichs et al. 2017 for recent discussions of the literature). The possible effect of salience cannot easily by gleaned from categorizing studies into being based on a salient or a not-so-salient shock in punishment, however, since methods, population under study, and context differ as well.

Our findings are of direct relevance to deterrence policy. Enhancing the salience of law enforcement can be a relatively swift and cheap way of reducing crime and disorder. It can reduce crime and disorder in two ways. First, salience can correct unjustified beliefs that enforcement policy is lax. As such, it can substitute for actual experience with the long arm of the law, cutting short a drawn-out process of adjustment of individual beliefs (as documented in Lochner 2007 and Rincke and Traxler 2011, for instance). It can be seen as an efficient way of bringing behavior in line with the expected punishment. Second, it may make potential offenders more attentive to the probability of being detected and the consequences thereof. Rather than having to increase the probability of getting caught, which is costly, or increasing the efficiency or effectiveness of law enforcement, which has proven to be difficult, simply attracting the attention to law enforcement activity may have the desired behavioral effect.[3] The treatment should not be seen as independent from the parameters of law enforcement, however. It does not involve any deception; it just emphasizes the current law enforcement policy.

Related to our paper are a series of recent studies in the tax compliance literature: Slemrod et al. (2001), Kleven et al. (2011), Fellner et al. (2013), Del Carpio (2014), Bott et al. (2015), Castro and Scartascini (2015), Chirico et al. (2016), Dwenger et al. (2016), Hallsworth et al. (2017) and Perez-Truglia and Trioano (2018) (see Slemrod 2018 for a review). These studies provide evidence for a deterrent effect of notifications in letters about the threat of being audited and the penalty for tax

[3] Our data do not allow us to assess whether the behavioral effect is driven by an adjustment in beliefs or a change in attention.

evasion.[4] Likewise, there is an empirical literature on the effect of prohibition and warning signs on illegal activity (see e.g. Keizer et al. 2011 and Nettle et al. 2012). Just like these interventions, ours is meant to make enforcement policy more salient. However, it does so in a different way. Rather than notifying potential offenders of future enforcement policy, our intervention provides a credible signal that enforcement is actually taking place.

Most similar to our approach is an intervention evaluated by Lu et al. (2016). They find that when the police sent cell phone text messages to drivers citing their recent traffic violations, the likelihood of future traffic violations reduced substantially. In other treatments, the police sent messages advocating safe driving or warnings about widespread use by the police of video cameras to detect traffic violations. These messages did not have any effect, suggesting that it is not the surprise of receiving a message from the police that drives the response. Obviously, a limitation of their treatment is that it only reminds people who were already fined in the past. Our treatment affects a much broader population of potential offenders. Moreover, our treatment is extremely inexpensive and does not require knowing the identity of the potential offenders.

Our study contributes to the literature on environmental monitoring and enforcement. Shimshack (2014) notes in his recent survey of the literature that "environmental monitoring and enforcement remain both understudied and controversial" (p. 339); in particular, "evidence on deterrence in European contexts is surprisingly rare" (p. 353). Shimshack sees "a promising and growing role for experimental evidence" (p. 353), citing Telle (2013) and Duflo et al. (2013) as leading examples of natural field experiments in this area. Our field experiment adds to this small, but growing body of experimental evidence.

Our paper also contributes to the broader literature on salience and decision making. How attention-grabbing cues – or camouflaged features – affect choices has been studied in several contexts, including product choice (Drèze et al. 1994; Chetty et al. 2009; Bordalo et al. 2013), price setting behavior (Finkelstein 2009; Grubb 2015), personal finance (Stango and Zinman 2014), social security

[4] See also Apesteguia et al. (2013) and Telle (2013) who study similar interventions within the context of a public library and a regulatory agency, respectively.

benefits (Brinch et al. 2017), and no-smoking laws (Rigotti et al. 1992). Apart from the literature discussed above, salience has not been studied within the context of illegal behavior.

The remainder of this paper is structured as follows. The next section presents the contextual background. Section 3 discusses the treatment, data collection, and empirical strategy. Section 4 presents the estimation results. Section 5 concludes.

2. Contextual background

Garbage disposal containers

The field experiment was conducted in the city of Heerlen in the south of the Netherlands from August 11 until October 25, 2013. Heerlen has a population of 87,000 and counts 286 garbage bag disposal locations and 72 glass and paper disposal locations (see Figure 1). Glass and paper containers tend to be concentrated in groups of four; garbage bag disposal containers tend to be stand-alone. Thus the latter type of containers are spatially far more dispersed.[5]

The part of an underground garbage bag disposal container (pictured on the left-hand side of Figure 1) that is visible at street level features a lid that is to be opened to dispose of garbage. It can only be used by nearby residents. It operates after inserting an electronic pass. Use of the container is recorded and costs 1 euro per time. Households receive a bill from the city annually. In contrast, use of the glass and paper disposal containers (pictured on the right-hand side of Figure 1) is free. These containers have a small opening for bottles or paper and are placed at central locations such as squares or thoroughfares.

As discussed in the introduction, illegal disposal of garbage bags and discarded household items next to the disposal containers is reported as a major nuisance in surveys. Even a minor tendency for

[5] The total number of glass and paper containers (rather than the number of container locations) is actually roughly similar to the total number of garbage bag disposal containers.

illegal disposal creates a sense of disorder that most residents strongly dislike: a rough estimate suggests that 95 percent of garbage bags in our sample are legally disposed (a similar estimate is not available for legal disposal of discarded household items).[6]

Figure 1. *Garbage bag disposal container (left) and paper and glass disposal container (right), featuring officers*

The private benefits of illegal disposal of a garbage bag consist of a euro saved and not having to put in the effort of opening the lid and pulling the lever. That is a small effort, but it requires bringing the electronic pass, the use of some force, and residents may get their hands wet or dirty.[7] Illegal disposal of household items such as a couch saves the effort of setting up an appointment for pick up by service workers of the Department of Sanitation or of legal disposal at the municipality collection depot.

[6] This estimate is based on the following back-of-the-envelope calculation. On average, a person produced 3.6 kilos of residual waste per week in Heerlen in 2014 (Statistics Netherlands 2015). Total production of garbage bags per week per container location is 55 garbage bags (3.6 kilos of residual waste per person per week*2.2 persons per household*60 households per container location*7/60 to convert kilos to bags). As discussed below, the Sanitation Department finds 2.75 illegally disposed garbage bags per location per week on average. This implies a rate of legal disposal of 95 percent.

[7] In very rare cases, doing the right thing is impossible, because the container is inoperative or other garbage blocks access to the container. From data we collected, we know that only 2 percent of the time garbage disposal containers cannot be used for technical reasons. We also know that in the vast majority of the cases where garbage had been dumped, it did not hinder residents from reaching the container and opening the lid. In 75 percent of the cases that any garbage was present in the baseline period, the total volume was less than 0.35 m^3 (the equivalent of 3.5 garbage bags).

The private costs of illegal disposal of a garbage bag consist of the expected penalty and the moral cost of not doing the right thing. For illegal disposal of household items, the perceived penalty is likely to be zero since the chance of getting caught for these items is close to zero, as we discuss below. A substantial part of offending is likely to be occasional in nature because illegal disposal of garbage has been found to be highly contagious (Dur and Vollaard 2015).

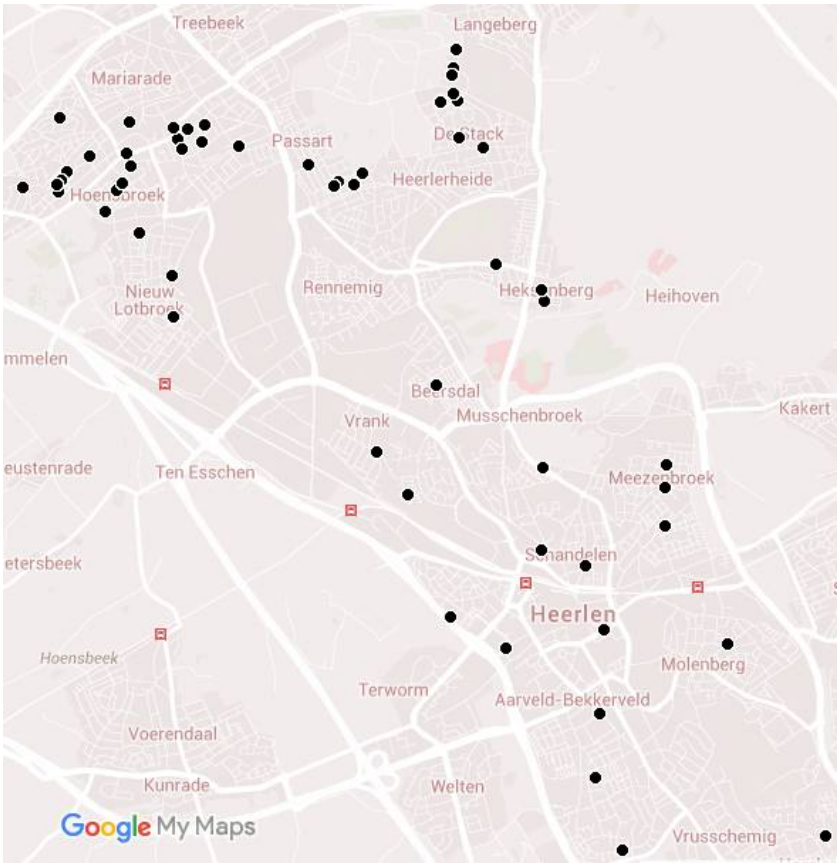
Law enforcement

About one and a half years prior to the experiment, the city of Heerlen selected 31 garbage bag disposal locations and 25 glass and paper disposal locations as 'hot spots', based on a qualitative assessment of the prevalence of illegal garbage disposal. The 56 hot spots are spread over the city, although a fair share is concentrated in the Hoensbroek neighborhood to the north (see Figure 2). As of mid-April 2012, the same two uniformed officers enforce the garbage disposal laws on each business day, year-round, at all of these 56 hot spot locations. They alternate a morning round and an afternoon round of about five hours each on a weekly basis. The order by which the locations are visited varies somewhat from day to day. The officers search for name and address identifiers in all illegally dumped garbage bags that they find. Catching an offender in the act is very rare (only 2 percent of fines). The probability of detecting households that illegally dispose large household items such as discarded furniture is close to zero: for the period that we have the officers' records, not a single fine relates to discarded household items. Once an address label is found in a bag, the officers visit the home of the suspect, and question him or her. If the suspect confirms wrongdoing, or at least is not able to provide a coherent explanation for the detected bag, he or she receives a fine to the value of 90 euros.

The officers search about 25 percent of illegally disposed garbage bags (based on data that we discuss in Section 3). They do not search all bags, because the locations are regularly cleaned and they visit a container location only once per day. In addition, they occasionally miss a round due to sick leave or a day off. In slightly less than 20 percent of searches, they find sufficient evidence resulting in the imposition of a fine, implying an average probability of detection of 5 percent (0.25*0.20). In other words, on average, a household that consistently puts one garbage bag next to a container on a weekly basis will be caught every 5 months. Obviously, if a household is only an occasional offender,

then the expected average duration until one is caught is much longer. For each illegally disposed garbage bag the expected penalty is 4.50 euros (0.05*90) on average. That is a lot more than the 1 euro saved for not using the container for legal disposal of a garbage bag. One explanation for the prevalence of illegal disposal is that the penalty for illegal disposal is not salient. After all, the officers are only present in a street for a short time and at times that most people are at work. In addition, the fine arrives in the mail two weeks after the home visit: unless the offender shares this information with others, no one else is likely to know about the penalty. An alternative, but less plausible, explanation for illegal disposal is that the perceived costs of operating the container are very high.

Figure 2. *Map of the area including the 56 container locations*



3. Identifying the behavioral response

Treatment

In the treatment condition, the officers put bright orange self-adhesive warning labels on illegally disposed garbage bags for a period of five weeks (September 9-October 11, 2013) at a random subset of the 56 locations. On the label it says: "Found by law enforcement. Fine: minimally 90 euros" (see Figure 3). The bright labels make the existing law enforcement activities much more visible to the residents, with a minimum of effort. Everything else remained unchanged.

To keep the labels visible to the public, the officers put searched garbage bags into new, slightly larger garbage bags and left them at the container location where they were found.[8] This routine was introduced in the baseline period (four weeks), continued during the treatment (five weeks) and after the treatment (five weeks). Apart from the labeling of garbage bags, a similar routine was followed at locations in the control group. In the past, the officers would put garbage into the container after inspection. Obviously, the old routine would render the new policy of making law enforcement more salient using labels on garbage bags infeasible.[9] The regular cleaning by the Department of Sanitation puts a limit on the duration that the warning labels are visible, something we return to later in this section.

Figure 3. *The self-adhesive warning label*

[8] Shortly after the start of the study, before the intervention started, the substitute garbage bags were found to be of too low quality and were replaced with transparent plastic wraps.

[9] The change in routine might have made law enforcement activities more salient at all locations, possibly limiting the effect of the warning labels. Since we do not have experimental variation in this routine, we cannot examine how it affected illegal disposal.

Note. Warning labels were only put on illegally disposed garbage bags, not on other types of garbage. The message reads: ‘Found by law enforcement. Fine: minimally 90 euros.’

Behavioral mechanisms

The treatment may increase the deterrent effect of existing law enforcement activities, either because beliefs about the expected penalty are adjusted upwards or because potential offenders become more attentive to law enforcement. In both cases, the effect may not be limited to the moment of observing the warning label. In addition to making law enforcement more salient, our intervention may also remind people of a prevailing social or intrinsic norm not to litter (Rege and Telle 2004). The treatment may strengthen feelings of shame or guilt when dumping garbage, as the labels make clear – both to potential offenders and observers – that this is a violation of law. This way, our intervention could strengthen the expressive significance and, hence, the deterrent effect of law (Kahan 1997).

The treatment may not only have favorable effects on behavior, however. First, the warning labels may indicate that law enforcement is largely toothless. At visited treatment locations, warning labels are ubiquitous but fines remain rare. In addition, some 75 percent of illegally disposed garbage bags are not searched by the officers and, hence, not labelled. Hence, the treatment may also lead to a downward adjustment of the perceived chance of getting fined. For this perception to take hold, residents should have sufficiently high priors about the probability to be caught. This seems unlikely given the cost-benefit considerations sketched earlier.

Second, the warning labels may signal that the officers have visited the container location, and that they will return the following day at the earliest. This may create an opportunity for illegal disposal that goes undetected. For this to be true, residents should know that the officers only visit a location once per day. This is not obvious since the officers alternate a morning and an afternoon round on a weekly basis. In addition, the resident should take the risk that the officers return earlier than the service workers from the Department of Sanitation who clean the location of all garbage, and that they get fined after all. Taken together, we do not expect that the treatment enables residents to outmanoeuvre the enforcement officers.

Third, the labels may signal that breaking the law is common, creating a bad example that residents may follow (Dur and Vollaard 2015). The bad examples were already there, however, and they are

now turned into a warning, making this adverse effect on behavior unlikely.[10] Moreover, if the treatment has a deterrent effect, the volume of illegally disposed garbage goes down, which reduces the invitation for illegal disposal.

Fourth, the treatment may increase the tendency to change tactics in order to evade law enforcement. The warning labels make it more salient when and where law enforcement officers are doing their work, possibly inviting residents to displace illegal disposal to what seem to be unmonitored container locations. We conduct a test for the presence of displacement in Section 4. In addition, given the increase in the perceived penalty, more residents may take care not to leave name and address identifiers in illegally disposed garbage bags, thus reducing the rate at which officers find evidence leading to a suspect. Our data show that detection rates in the treatment group are indeed lower in the treatment period relative to the baseline period and do not change much in the control group, but this could also be the result of selection rather than a change in behavior. If it is behavior, then our estimated effect on illegal disposal is probably somewhat smaller than it would have been in the absence of evasion.

To conclude, these four possible adverse effects may drive down the treatment effect. We have reason to believe that the adverse effects are likely to be limited, however, with displacement from treated to untreated locations as the possible exception.

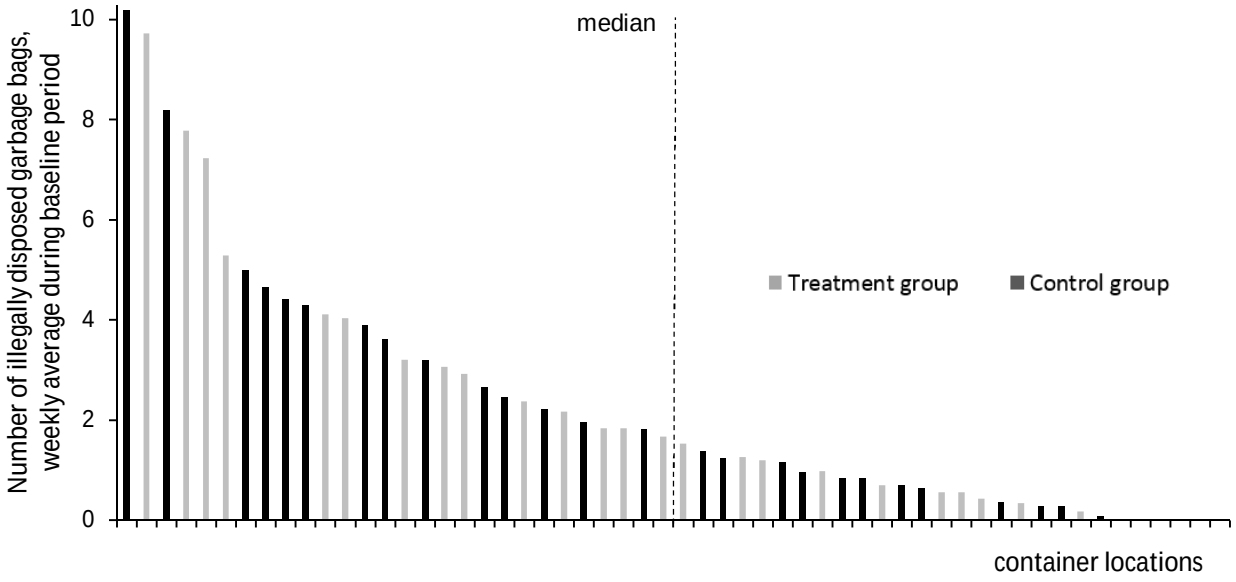
Randomization

We assigned container locations to treatment based on matched pair randomization. We ranked locations based on the aggregate volume of illegally disposed garbage bags during the first three weeks of the data collection (August 11-31, 2013). Out of each of the 28 pairs of container locations, we randomly selected one for the treatment group. We base the randomization on illegally disposed garbage bags, because the warning labels are attached to garbage bags only. The randomization was conducted one week before the start of the treatment to allow time for instruction of the officers.

[10] If the labels do not discourage illegal disposal fully, resulting in a collection of labeled and unlabeled bags next to the container, the treatment effect may be reduced or even reversed, as people observe that others have not been deterred by the labels, which sets an example for others to do the same. See Keizer et al. (2011), who provide empirical support for this idea in the context of littering.

Figure 4 shows the pre-treatment values for each of the locations (for the full baseline period rather than the first three weeks only). For illustrative purposes, the figure shows the number rather than the volume of illegally disposed garbage bags.[11] Clearly, illegal disposal greatly varies between locations, something we return to below.

Figure 4. *Average number of illegally disposed garbage bags per location per week, pre-treatment period*



Data collection

Service workers of the Department of Sanitation record the volume of illegally disposed garbage when they clean up the areas around the containers between 7.30 am and 2.30 pm. They distinguish four types of illegally disposed garbage: garbage bags (46 percent of the total volume of illegally disposed garbage), discarded household items (38 percent) and paper and glass (17 percent). The service workers were trained to estimate the volume of garbage (in cubic meters), rather than to count the number of items. Occurrence of the different types of garbage is strongly correlated, which

[11] We take 0.1 m^3 as the volume of one garbage bag. Garbage bags are of uniform size and tend to be filled to the brim. Strong bunching around multiples of 0.1 m^3 in the recorded volume of garbage bags suggests that the service workers indeed take this to be the approximate volume of a garbage bag. This is in line with Robin (2004), who estimates that the approximate volume of a full garbage bag is equal to 0.09 m^3.

is in line with the finding that an act of illegal disposal provides an invitation for others to do the same (Dur and Vollaard 2015). During the baseline period, conditional on the presence of illegally disposed garbage bags, the chance of also observing other types of garbage is 66 percent.

The workers also record whether a container is out of order, which rarely happens. Out of concern for privacy, the municipality did not provide data on the recorded use of the garbage bag disposal containers.

The frequency of cleaning varies across locations. Glass and paper disposal locations are cleaned six times per week; garbage bag disposal locations three to six times per week – according to a fixed schedule. As a consequence, the number of observations varies from day to day. To limit imbalance of our data, we collapse the data from daily to weekly summed volumes of illegally disposed garbage per container location.

The law enforcement officers provided us with their records, including the number of searched bags and the number of fines. The officers' data allowed us to compute the search rate and detection rate that we discussed previously.

Outcome measure

Even though the 56 container locations were once characterized as 'hot spots', the amount of illegal disposal greatly varies across container locations (see Figure 4). The strong variation in illegal disposal is of consequence for our analysis, since the treatment is unlikely to lead to a similar absolute change in illegal disposal across the various locations. We therefore have to scale the volume of illegal disposal per location, for instance by the average volume of illegal disposal at that location during the baseline period. Scaling by illegal disposal of garbage bags is impeded because the baseline volume of illegally disposed garbage bags is very low or even zero at some locations. That would give changes at locations with very low baseline levels of illegally disposed garbage bags an unduly great weight in the estimation of treatment effects. For this reason, we use the volume of illegal disposal of any kind of garbage (garbage bags, discarded household items, paper and glass) scaled by

its baseline level as our primary outcome measure.[12] After presenting the results of our default specification, we also explore how much of the treatment effect can be attributed to changes in the volume of garbage bags only.

Table 1. *Baseline characteristics and randomization check*

	Treatment locations	Control locations	P-value difference
Illegally disposed garbage bags (m^3)	0.22 (0.29)	0.21 (0.30)	0.84
Illegally disposed garbage (m^3)†	0.61 (0.76)	0.62 (0.76)	0.87
Number of searched bags	0.65 (1.74)	0.41 (1.61)	0.28
Number of detected offenders	0.11 (0.49)	0.06 (0.31)	0.42
Number of container locations	28	28	
Number of observations	112	112	

Note. Observations by container location and week. Standard deviation between parentheses. Baseline period is August 11-September 7, 2013. (†) Includes garbage bags, disposed household items and paper and glass.

Randomization check

Table 1 summarizes the baseline characteristics of the treatment and control locations in our sample. The matched pair randomization guaranteed balance between the treatment and control locations with respect to the presence of illegally disposed garbage bags. On average, 0.22 m^3 of garbage bags are illegally disposed per week at the 28 treatment locations, and a similar volume at the control locations (equivalent to 2 to 3 bags per location per week on average). The difference is minimal and not statistically significantly different from zero. The total volume of illegally disposed garbage is also similar between the two groups. As discussed above, our default specification is based on the volume of any type of illegally disposed garbage rather than the volume of illegally disposed garbage bags only. The number of searched bags is somewhat higher in treatment than in control locations. The higher number of searched bags at treatment locations is primarily due to a strong one-off increase at three locations in the third week of the baseline period. More generally, the number of

[12] At one container location, illegal disposal of any kind of garbage was zero during the baseline period. For this reason, before transforming our outcome variable from levels to rates, we add one half of the lowest, non-zero value observed during the baseline period to the outcome variable.

illegally disposed bags at a location, and also the number of searched bags, is characterized by wild fluctuations. Given the high standard deviation of the number of searched bags, the difference between treatment and control is not statistically significant. Excluding week 3, the means for the two groups are virtually identical. Similarly, the number of detected offenders, which is a direct function of the number of searched bags, is higher in treatment locations than in control location, but the difference is not statistically significant either.

Treatment compliance

The law enforcement records show that labelling of garbage bags started in the first week of the treatment and continued for five weeks (calendar weeks 37-41 in 2013). Given the regular cleaning activities by service workers, not all garbage bags disposed at treatment locations were labelled. As discussed in the previous section, on average some 75 percent of illegally disposed bags were not searched.[13] At treatment locations, a bag not searched meant a bag not labelled. In other words, the officers complied with the treatment, but treatment intensity was low given their routines. The percentage searched varied greatly by week, however, and so did the percentage of bags labelled at treatment locations. The number of bags that could be labelled was much lower in even weeks than in odd weeks, in line with the alternating afternoon and morning rounds of the officers. In even weeks, 90 percent of bags were not labelled; in odd weeks 60 percent. The cause of the variation in treatment intensity is the daily cleaning between 7.30 am and 2.30 pm. Cleaning limits the duration that the warning labels are visible, which also affects the morning round, but it prevents application of the treatment altogether if there are no illegally disposed bags, which is common to afternoon rounds. We return to this issue in the next section.

The data show that law enforcement routines other than the labelling remained unchanged during the experiment. The officers always visited all 56 locations on a daily round. The percentage of bags searched and the detection rate were similar between the treatment and control group. More generally, we find that law enforcement did not go into overdrive during the experiment. The monthly number of fines for illegal disposal of garbage during August-October 2013 varied between

[13] Table 1 shows that on average 0.2 m^3 of garbage bags were illegally disposed per location per week. This is equal to a little more than two garbage bags. Given an average number of searched bags of about 0.5 per week, the percentage of bags searched is about 25 percent.

26 and 31, which is within the usual range, albeit somewhat higher than in earlier months because the officers did not take long vacations during the experiment.

4. Estimation results

To estimate the effect of the treatment on the volume of illegally disposed garbage, we estimate the following equation:

(1) $G_{i,t} = \alpha T_i P_t + \sigma_i + \lambda_t + \varepsilon_{i,t}$

where $G_{i,t}$ is the volume of illegally disposed garbage at location *i* in week *t*, scaled by the average weekly volume of illegally disposed garbage at that location during the baseline period. $T_{i,}$ denotes the treatment group and P_t the treatment period; the product of T_i and P_t is 1 for the treatment group during the treatment period and 0 otherwise. α is the parameter of interest: the change in the rate of illegally disposed garbage as a result of the treatment. We include container location-fixed effects, σ_i,[14] and week-fixed effects, λ_t. The error term $\varepsilon_{i,t}$ is clustered at the level of container locations.

Table 2 shows the estimation results based on equation (1). On average, we find a negative and marginally statistically significant effect of the treatment (column 1). The point estimate suggests a 30 percent reduction in illegal disposal of garbage.

In column (2), we explore how weekly variation in treatment intensity affects the results. As discussed in the previous section, treatment intensity was about four times higher in odd weeks than in even weeks (40 percent versus 10 percent of bags searched and labelled), depending on whether the officers did their round at a time of day that many locations still were to be cleaned or had been cleaned already. Since the variation in treatment intensity is orthogonal to illegal disposal of garbage, we allow the treatment effect to vary between odd weeks (with morning rounds) and even weeks (with afternoon rounds). Our estimate for the morning rounds, when treatment intensity is relatively high, is negative, almost twice as high as the default estimate, and statistically significant at the 5 percent level. The estimate for the afternoon rounds is small and insignificant. The two coefficients are statistically significantly different at the 1 percent level.

[14] The location-fixed effects are not redundant despite the scaling of the dependent variable because of the issue described in footnote 12.

Table 2. *The effect of warning labels on illegal disposal of garbage*

Dependent variable: rate of illegally disposed garbage	(1) Overall	(2) By am/pm round	(3) By type of location	(4) By pre-treatment level
Treatment†	-0.29* (0.17)			
Treatment * a.m. round		-0.55** (0.25)		
Treatment * p.m. round		0.10 (0.11)		
Treatment * garbage bag disposal locations			-0.50* (0.30)	
Treatment * glass/paper disposal locations			-0.10 (0.15)	
Treatment * cleanest locations				-0.41 (0.28)
Treatment * messiest locations				-0.11 (0.11)

Note. (†) Here and in all following instances, 'Treatment' is defined as $T_i P_t$, treatment group multiplied by treatment period. Observations by container location and week. Number of observations is 504. Between parentheses standard errors clustered by container locations. Not shown are estimation results for location-fixed effects and week-fixed effects. Further, column (3) includes the interaction between the indicator variable for the type of location and the treatment period; column (4) the interaction between the indicator variable for an above-median baseline illegal disposal and the treatment period. *p<0.10; **p<0.05; ***p<0.01.

In column (3), we allow the treatment response to differ between the two types of garbage disposal locations. The estimate for locations with garbage bag disposal containers is considerably larger than the estimate for locations with glass and paper disposal containers. The difference between the two estimated effects is not statistically significant, however, because both estimates are fairly imprecise.

A difference in the behavioral effect between the two types of locations was not anticipated. We can provide four reasons for this difference. First, since glass and paper containers are further away from homes, the warning labels are less conspicuous, making exposure to the treatment weaker. Second, the type of offender may differ. While the residents going to a glass and paper container with a garbage bag are lawbreakers by definition, such need not be the case at the other type of locations. Third, at locations with garbage bag containers people can easily switch to the legal option by putting the bag in the container rather than next to it, whereas at glass and paper containers the only way of doing the right thing is to not dispose the garbage bag at that location. In other words,

the costs of the legal alternative are lower at locations where we find a large treatment effect. Fourth, visibility of the warning labels is also lower at glass/paper containers because they are also cleaned on Saturdays, whereas most garbage bag disposal containers are cleaned on business days only.

In the last column of Table 2, we explore how the treatment response depends on the rate of illegal disposal at a location during baseline, which we know to vary greatly. The type of households – and their response to the treatment – may differ across locations. For instance, relatively messy locations may be frequented by people who are not easily deterred by penalties. Besides different location-specific characteristics, a difference in the treatment response between the two groups may be due to the greater visibility of warning labels at locations with lots of illegally disposed garbage. Obviously, the number of bags labelled by the enforcement officers is strongly positively correlated with the number of illegally disposed bags. In the randomization, we blocked on the baseline level of illegal garbage disposal, allowing us to explore heterogeneity in the treatment effect along this dimension. We divide the sample into two groups: one group with below-median pre-treatment levels of illegal disposal and another group with above-median levels.

Illegal disposal went down as a result of the treatment by some 40 percent on average at locations that were cleanest in the baseline period, but the estimate is imprecise. It went down by 11 percent at locations that were messiest in the baseline period. The effect for the latter subsample is also imprecisely estimated.[15] The two coefficients are not statistically significantly different.

To conclude, the estimation results reported in Table 2 point towards lower rates of illegal disposal in response to the treatment, particularly for weeks with a relatively high treatment intensity and at garbage bag disposal containers.

Spillover effects

[15] It should be noted that the ranking of locations from clean to messy is not fully stable. The ranking is based on a four-week baseline period. Based on the estimation results of the specification in column (4) of Table 2, we find evidence for reversion to the mean. The interaction term between the group of clean locations and the treatment period is positive and statistically significant (not shown).

The treatment effects reported in Table 2 describe the effects of the warning labels on the volume of all types of garbage together. In Table 3, we examine whether the response differs by type of garbage. We expect the treatment to have the strongest effect on garbage bags, as the warning labels were attached to garbage bags only, not to other types of garbage. Moreover, people may understand that the detection probability is much smaller for types of garbage other than garbage bags, rendering the warning messages less effective (see Section 2). On the other hand, a favorable treatment effect on garbage bags may spill over to other types of garbage because a cleaner location has been found to result in less illegal disposal of any garbage (Dur and Vollaard 2015).

Table 3. *Spillover effects of the treatment*

Dependent variable: rate of illegally disposed garbage	Average treatment effect
Spillovers to illegal disposal of other types of garbage	
1. All types of garbage	-0.29* (0.17)
2. Garbage bags only	-0.25* (0.14)
3. Other types of garbage only	-0.03 (0.11)
Spillovers from treated to untreated locations	
4. Subsample: no treated locations nearby	-0.05 (0.18)
5. Subsample: at least one treated location nearby	-0.67* (0.33)

Note. Observations by container location and week. Number of observations is 504 (261 in row 4; 207 in row 5). Between parentheses standard errors clustered by container locations. Not shown are estimation results for container location-fixed effects, week-fixed effects. *p<0.10; **p<0.05; ***p<0.01.

Table 3 compares the estimated effect on overall illegal disposal (row 1) with the estimated effect on garbage bags only (row 2) and on other types of garbage only (row 3). We scale each dependent variable by the amount of illegal disposal of any kind of garbage during the baseline period. The results show that the treatment effect is almost completely due to a reduction in the number of illegally disposed garbage bags. Spillovers to other types of garbage are largely absent, something we return to below.

Next, we examine whether the estimated treatment effect is affected by displacement from treated to untreated locations. Residents may displace illegal disposal of garbage from treated locations to

locations that they believe to be untreated. Displacement is not without its costs, think of a longer walking distance to another location, but it has the possible benefit of avoiding detection. Spillovers may also be positive. Upon noticing the warning labels, residents may believe that the officers also visit locations that are actually untreated.

To assess the presence of spillovers, we split our sample of 56 locations in two subsamples. One subsample of locations consists of treatment and control locations that have one or more treated garbage disposal locations nearby, defined as being within walking distance (250 m). In this subsample we expect control locations to be affected by the nearby presence of treated locations. The other subsample consists of locations that also have other garbage disposal location nearby, but none that are treated. In this subsample, the lack of nearby treatment locations makes it arguably less likely that control locations are affected by any spillover effect. By comparing the estimated treatment effects in these two subsamples, we get an idea about how important spillovers are in our setting.[16]

We present the estimation results for these two subsamples in row (4) and (5) of Table 3. We find the estimated treatment effect to be small and statistically insignificant for the subsample of locations without treated locations nearby, and to be considerably larger and statistically significant for the subsample where the control group is likely to be affected by spillovers. This suggests the presence of substantial negative spillovers. Displacement leads to a greater volume of illegally disposed garbage at control locations after all, increasing the difference between the treatment and control group.

Post-treatment period

After the end of the treatment, the officers continued their routine of leaving searched bags next to the container at all 56 locations for another five weeks. The treatment effect may carry over to those weeks, since residents may have updated their beliefs about the expected penalty as a result of the treatment, as argued in Section 3.

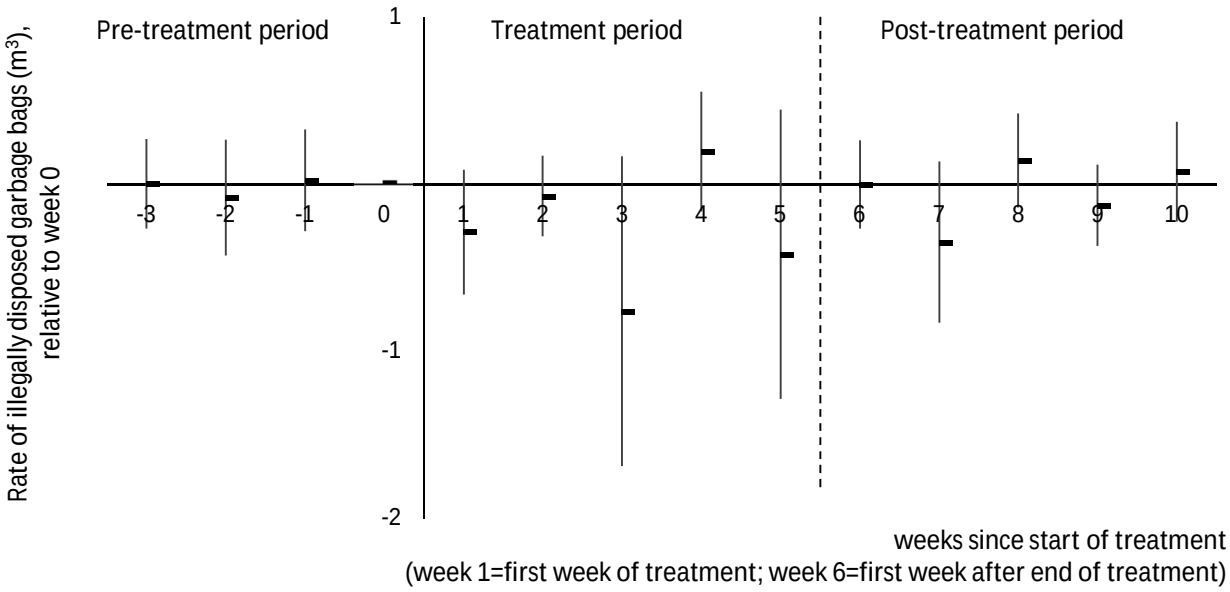
[16] We exclude four container locations that do not have another container location within walking distance, resulting in 468 rather than 504 observations for both samples together (see Table 3).

For an analysis of the behavioral response after the end of the treatment, we focus on illegal disposal of garbage bags. If the treatment had a persistent effect on behavior at all, chances are we can detect it for garbage bags. To graphically illustrate how behavior evolved, we estimate the difference in illegal disposal between the control and treatment container locations for each week before, during, and after the experiment. We estimate the following equation:

(2) $G_{i,t} = \sum_{t=1}^{Z} W_{i,t}\,\alpha_t + \sigma_i + \lambda_t + \varepsilon_{i,t}$

where $G_{i,t}$ is the volume of illegally disposed garbage bags at location *i* in week *t*, scaled by the average weekly volume of illegally disposed garbage at that location during the baseline period. $W_{i,t}$ is a vector of weekly indicator variables which are 1 for container locations in the treatment group and 0 for container locations in the control group; vector α_t represents the parameters of interest. Again, we include container location-fixed effects, σ_i, week-fixed effects, λ_t, and cluster the error term $\varepsilon_{i,t}$ at the level of container locations.

Figure 5. *Illegal disposal of garbage bags in treatment vs. control, relative to last week of baseline period*



Note. The figure plots coefficients α_t from estimation of equation (2). The bars show the 95 percent confidence interval. Number of observations 784.

Figure 5 shows the estimation results based on equation (2). The coefficients show the estimated difference in the rate of illegal disposal of garbage bags between the control and treatment group. All coefficients are estimated relative to the last week of the baseline period, which is set to zero. The estimated coefficients for the pre-treatment period (weeks -3 to 0) show that the treatment and control group do not have a different trend in illegal disposal, one of the assumptions underlying our empirical approach. As soon as the treatment starts (week 1), the volume of illegally disposed garbage bags drops at the treatment locations relative to the control locations. In the following weeks, we see a substantial decrease of illegal disposal in odd weeks (particularly in week 3), but no effect in even weeks. This difference in treatment response between even and odd weeks is in line with the strong variation in treatment intensity that we discussed earlier (see also column (2) in Table 2).[17]

[17] Figure 5 shows that the difference between even and odd weeks continues into the post-treatment period. This is surprising because the number of labelled garbage bags no longer varies after the end of the treatment. The number of labelled bags is zero in both even and odd weeks. The most likely explanation is that the warning labels made residents at treatment locations sensitive to signs of searched bags. After a search, the officers rolled a bag into transparent plastic and left this package next to the container. Searched bags left at the container location may have become another signal for law enforcement activity. This goes for the

Overall, the treatment effect seems to taper off once the officers stop using the warning labels. This finding is in line with the strong correlation between treatment intensity and the size of the behavioral response during the treatment period. Apparently, households show a strong response to observing the warning labels, but this effect does not carry over to times where no labels are visible. The estimates for the treatment period and the post-treatment period are not statistically significantly different however (not shown), rendering the evidence suggestive.

5. Concluding remarks

The economic analysis of crime has mainly focused on how the probability of conviction and the severity of punishment jointly affect an individual's inclination to commit crime. Typically, potential offenders are assumed to be aware of these parameters and to incorporate them in their decision making. Not all potential offenders may hold correct beliefs, however (Durlauf and Nagin 2011). Moreover, even when beliefs are correct, the level and likelihood of penalties may not always play a dominant role in decision-making, because people cannot attend to everything at once (Bordalo et al. 2013). In such situations, it may pay off to make enforcement policy more salient, as suggested by Jolls et al. (1998). By doing so, potential offenders may adjust their beliefs about the likelihood of conviction and the severity of punishment upwards. Such a policy also increases the likelihood that potential offenders take these factors into consideration before committing an illegal act.

We put this idea to the test in a context where we can be fairly confident that people underestimate the consequences of breaking the law. We examined illegal dumping of garbage bags by citizens in residential areas in a city in the Netherlands. In the baseline, chances of getting caught for illegal dumping are about 5 percent and the fine is 90 euro, implying an expected penalty of about 4.50 euro. The cost of the legal alternative (putting the garbage bag into the container) is just 1 euro and a bit of effort. In cooperation with local law enforcement, we set up a field experiment that made enforcement activity more salient by putting bright orange warning labels on illegally disposed garbage bags. We find sizeable responses to the treatment, particularly in weeks with high treatment

treatment group, where this package used to be accompanied with the bright warning label, not for the control group, where a searched bag may not be identified as such. For this to be true, a sizeable number of residents at treatment locations should have become familiar with the treatment over the course of five weeks, which is not unlikely.

intensity. We also find indications for displacement of illegal dumping from treated to untreated locations.

Our paper is a first attempt at proof of concept. It would be worthwhile to replicate our experiment in similar or different settings. One application that is close to the one studied in this paper is separation of household waste. Van Soest and Vollaard (2018) evaluate how introducing a punishment for incorrect separation of waste affects household behavior. In the treatment condition, law enforcement officers attach fairly large, brightly-colored warning labels to garbage containers when they detect a violation. Other applications that we have come across are large posters put in windows of illicit cannabis-grow houses with the message 'Another grow house busted by the police', and a digital traffic sign stating the number of tickets issued at an intersection that day.

Let us end with a cautionary note. Interventions like the one studied here may also have perverse effects. In particular, if potential offenders believe that enforcement policy is more severe than it actually is, then making the actual severity more salient may backfire and result in more rather than less illegal behavior. Hence, before implementing such policies, it is key to assess current beliefs of potential offenders about enforcement policy.

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