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Thou Shalt Recycle: How Social Norms of Environmental Protection Narrow the Scope of the Low-Cost Hypothesis

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Abstract

According to the "low-cost hypothesis" (LCH), attitudes explain behavior only if complying with personal convictions requires little effort. Environmental research has seized this argument to explain moderate participation in pro-environmental action against a backdrop of rising environmental awareness. However, evidence for the LCH remains ambiguous, and recent studies have reported contradictory results. Here, we reconcile prior findings on household waste recycling and argue that many environmental behaviors evolved into every day, "normal" practices increasingly encouraged by social norms, and thus slip out of the LCH's scope. We combine a natural experiment exploiting households' variation in geocoded walking distances to drop-off recycling sites in Munich, Germany ($N = 754$) with an independent online survey ($N = 640$) measuring local intensities of recycling norms for two distinct waste categories, plastics and glass. Our results suggest that normative change narrows the LCH's scope to include only environmental action for which normative expectations are weak.

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Western societies have grown increasingly sensitive to questions of environmental protection and sustainable use of natural resources. Behavioral adjustments, however, have lagged considerably behind. For example, private households in Germany have reduced carbon dioxide emissions by only 7.1% over the last decade (Federal Statistical Office, 2016a). As a result, many environmental protection measures remain ineffective. In this context, research on environmental behavior can aid the search for effective approaches to environmental policy.

One important area of such policies has been the promotion of appropriate household waste disposal. Despite clear advancements made since the 1970s, participation in household waste recycling is far from complete. In Germany, annual per capita generation of recyclable waste amounts to 149 kg; however, private disposal of glass, plastics, paper, and metals in the designated containers reaches only 75 kg (Federal Statistical Office, 2016b).

Moderate participation in recycling has become a textbook example in academic literature for the complex relation between attitudes and behavior (e.g., Bamberg & Möser, 2007; Hines, Hungerford, & Tomera, 1987). One group of studies finds that the correlation between environmental concern and environmental action diminishes as behavioral costs increase (Black, Stern, & Elworth, 1985; Corraliza & Berenguer, 2000; Derksen & Gartrell, 1993; Diekmann & Preisendörfer, 1998).[1] Whereas attitudes and behaviors correspond in situations of little inconvenience, they diverge as choosing the environmentally friendly option requires greater effort. Diekmann and Preisendörfer (2003) formalized this finding into what is known as the "low-cost hypothesis" (LCH).

Evidence for the LCH, however, has remained ambiguous, and some have called into question its explanatory power (e.g., Guagnano, Stern, & Dietz, 1995; Kaiser & Schultz, 2009; Schultz & Oskamp, 1996). The majority of findings against the LCH emanate from studies utilizing the introduction of curbside collection as an experimental manipulation of recycling effort. Most recently, Best and Kneip (2011) found no evidence for the LCH based on such a rigorous field-experimental methodology, but the opposite: Following a reduction in recycling effort, environmental concern becomes a less important explanatory factor for recycling participation. Consequently, pro-environmental attitudes make no difference for households with low costs (curbside collection) but sustain recycling behavior in high-cost situations (drop-off). In the end, the authors note that "the puzzle of large variation in effects from the previous research remains unsolved" (p. 928).

We aim to reconcile these seemingly contradictory findings on the LCH's tenability in recycling research. We choose recycling as an illustration to demonstrate how social norms moderate the relationship between attitudes and behavior. We argue that since the 1980s and 1990s—when most researchers reporting results in favor of the LCH collected their data—recycling has developed into a "normal" practice (Thomas & Sharp, 2013), increasingly affected by social norms and day-to-day observations of others' compliance (Bicchieri, 2006; Cialdini, 2007). As recycling becomes more normatively charged, social penalties for nonparticipation rise. This rise in social costs for nonparticipants alters the trade-off between pro-environmental and convenience-driven actions such that in low-cost situations, even the less concerned are more likely to dispose of household waste in a socially acceptable way, that is, by recycling. At the same time, we expect that social norms will reinforce resistance to behavioral costs for the highly concerned.

Unlike Ajzen's (1991) theory of planned behavior—probably the most common model for explaining pro-environmental behavior by intentional actors (see, for example, Bamberg & Möser, 2007; Oom do Valle, Rebelo, Reis, & Menezes, 2005)—our approach does not predict behavior from an additive function of attitudes, social norms, and contextual motivators but focuses on the interactions of those effects. Rather than discarding the LCH altogether, we posit that its scope conditions include only environmental behavior for which social norms are weak and trade-offs remain intact.

To test this conjecture, we draw on a geocoded dataset from Munich, Germany, exploiting residents' "as-if" randomization to recycling effort due to exogenous variation in walking distances to households' nearest drop-off recycling sites. We combine this natural experiment with survey data on residents' self-reported environmental concern and recycling participation (N = 754). Most importantly, we differentiate the recycling of two distinct waste categories, plastics and glass. Plastic recycling still constitutes an uncommon disposal strategy, with only 50% of our survey respondents reporting full participation. Social norms enforcing participation are correspondingly weak. Glass recycling, on the other hand, is much more common in our sample (80% participation) and, in accordance with this rate, discarding glass in residual waste bins is frowned upon in Munich neighborhoods. To solidify this argument, we complement our design with an independent online survey (N = 640) measuring local intensities of social norms for recycling in both waste categories.

Unlike most studies on the LCH in recycling research, we introduce a continuous measure of recycling effort that permits us to address questions on the relative importance of environmental concern and convenience. Based on our estimates as to how both effects combine, we provide refined policy recommendations for urban waste management. Our continuous cost measure also allows a fairer test of the LCH than do curbside-collection designs, in which sharp reductions in recycling effort bring the cost of choosing the ecological option literally to zero. As the recycling effort approaches zero, however, more and more individuals recycle irrespective of their environmental concern, implying mechanisms guiding recycling participation in accordance with the "ABC theory" of environmental behavior (Guagnano et al., 1995): If external conditions make choosing pro-environmental behaviors increasingly convenient, intrinsic motivations will no longer determine individual participation in environmental protection. Focusing on differences in recycling effort within a stable drop-off regime, we explicitly exclude this scenario from our respondents' decision space, leaving the general trade-off between pro-environmental behavior and more convenient alternatives intact.

Costs, Attitudes, and Their Interaction

Social scientists typically conceptualize environmental behavior as a problem of collective action (Olson, 1965; Ostrom, 1999): While the collective clearly benefits from joint participation in environmental protection, individual incentives for nonparticipation may lead to a disconnect between individual motivations and social interest. This gap widens as individual costs increase, rendering participation in promoting the public good less likely. Therefore, individuals should adhere to environmentally friendly behavior more often when the effort to do so is minimal (Maki, Burns, Ha, & Rothman, 2016; Steg, Bolderdijk, Keizer, & Perlaviciute, 2014). Hence, we expect:

> **Hypothesis 1:** When participation requires little effort, the probability of recycling is higher.

Internalized personal norms (Ajzen & Fishbein, 1970; Schwartz, 1977) also affect environmental behavior. The association between attitudes toward environmental protection and ecological behavior is often weak and subject to strong moderating influences (Bamberg & Möser, 2007; Hines et al., 1987). Still, individuals with higher environmental concern typically exhibit more ecologically sound behavior (Fransson & Gärling, 1999; Lindenberg & Steg, 2007), particularly with regard to recycling (Best & Mayerl, 2013; Oom do Valle et al., 2005). Hence, we expect:

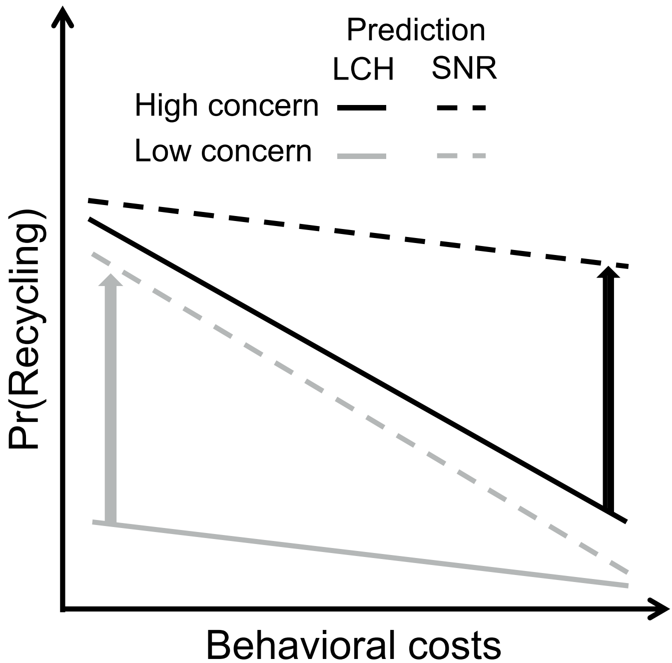

Figure 1. Theoretical predictions.
Note. The solid lines indicate mean probabilities of recycling according to the LCH (black for the highly concerned, gray for the less concerned). The dashed lines represent the same associations under a social-norm regime (SNR): Due to the social costs of nonparticipation, recycling rates should increase among the less concerned (gray arrow) and social norms should reinforce the resistance to behavioral costs for the highly concerned (black arrow).

Hypothesis 2: The environmentally concerned have a higher probability of recycling.

Building on these arguments, the LCH suggests that attitudes influence behavior more strongly when following one's good intentions involves little inconvenience (Diekmann & Preisendörfer, 2003). This implies that the environmentally concerned act considerably more ecologically than the less concerned—so long as doing so imposes no large costs. If the inconvenience of choosing the environmentally friendly option increases, however, behaviors in both groups converge (see Figure 1, solid lines). Hence, the LCH implies that,

Hypothesis 3: Environmental concern ceases to determine recycling participation as effort increases.

Social scientists have offered various related explanations for this interaction hypothesis. Diekmann and Preisendörfer (2003) suggest that individuals complying with their personal norms of environmental protection receive a greater utility from choosing pro-environmental action. For those with high environmental concern, the trade-off between the convenience of not recycling and the tediousness of recycling shifts more easily toward the latter due to additional benefits from adherence to one's own moral obligation. "Depending on . . . the intensity of attitude, the utility of complying with the norm may compensate for the cost difference of the pro-environmental behavior relative to its alternative" (Diekmann & Preisendörfer, 2003, p. 450). Personal attitudes, however, cease tipping the balance toward ecological options as compliance becomes increasingly tedious. In another formulation, Lindenberg and Steg (2007) posit that, in low-cost situations, the salience of environmental attitudes ceases to compete with alternative human motivations such as economic and hedonic goals. In a similar vein, Kirchgässner (1992) argues that in low-cost situations "soft incentives like those provided by moral rules can have a much stronger impact than (economic) hard incentives" (p. 305). Corroborating these arguments, experimental game theorists find fairer and more cooperative behavior in low-stake environments, whereas raising the stakes increases selfishness, "shifting behavior away from an overly socially desirable presentation of oneself to a more realistic one" (Camerer & Hogarth, 1999, p. 8).

Social Norms and the Narrowed Scope of the LCH

This article concerns itself less with the general relationship between attitudes and behavior than with the question of whether the LCH holds in situations in which others' normative expectations rather than the focal actor's behavioral costs and personal stance increasingly determine behavior. Triggered by changes in legislation and high levels of environmental awareness, recycling has experienced a substantial upturn in most Western societies. In their review on the now widespread practice in the United Kingdom, Thomas and Sharp (2013) note that "[t]here is clearly a trajectory from [recycling] being a marginal activity to normalisation and the growth in the adoption of recycling behaviour has been influenced by changing attitudes, provision of facilities, information and communication campaigns and the influence of others' behaviour" (p. 14). Participation in recycling, one can argue, emerged from a particular behavior by the concerned to a more or less standard behavior among the general population. Accompanying this trend, social norms have come increasingly to govern the socially visible act of recycling.[2]

A social norm not only specifies "what ought to be done" but also entails the "promise of social sanctions" (Cialdini, Reno, & Kallgren, 1990, p. 1015). Noncompliance thus incurs additional costs to the perpetrator. While such penalties are purely cognitive in the case of internalized personal norms or attitudes, in that of social norms they become extrinsic. This understanding of individual consequences of norm violation is well established in social psychology (Festinger, 1957; Schwartz, 1977) and a wide variant of rational-choice theory (Opp, 2013; Ostrom, 1998).

Following Cialdini (2007) and Cialdini et al. (1990), one can unite informal social rules under the general rubrics of "injunctive" and "descriptive" norms. Injunctive norms, on the one hand, characterize perceptions of others' approval, generalizing what Bicchieri (2006) calls "normative expectations" and Ajzen (1991)—focusing on important others' perceived approval—operationalizes as "subjective norms."

Descriptive norms, on the other, stem from others' observable actions, which inform empirical expectations as to what is morally acceptable in a given situation. These transport information about adaptive behavior in the sense of "[i]f a lot of people are doing this, it's probably a wise thing to do" (Cialdini, 2007, p. 264). As descriptive norms depend on current prevalence, they are prone to social spreading (Keizer, Lindenberg, & Steg, 2008; Keuschnigg & Wolbring, 2015) and thus highly sensitive to cultural change. This property makes descriptive norms particularly helpful in explaining both sudden changes and different rates of pro-environmental behavior in closely related domains.

Anecdotal evidence from Ireland's taxation of plastic bags illustrates the cumulative power of descriptive norms. Shortly after introducing a 33-cents tax on plastic bags in 2003, their use declined by 94% (Rosenthal, 2008). The newspaper accounts describe not the negligible increase in price but a dramatic change in people's perception of plastic bags as responsible for this drop. For example, it cites one local shopper as stating "[w]hen my roommate brings [a plastic bag] in the flat it annoys the hell out of me." Systematic field experiments on households' energy saving (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007) and hotel guests' towel reuse (Goldstein, Cialdini, & Griskevicius, 2008) validate the resounding impact of descriptive norms. Subjects receiving information on others' exemplary behavior adopted an environmentally friendly choice more often than did controls receiving standard environmental messages.[3]

Increased rates of recycling should, by the same informational mechanism, make social norms for appropriate waste disposal more salient. As recycling grows normatively charged, social costs for nonparticipants rise. Such a social-norm regime (SNR) alters the trade-off between choosing pro-environmental versus convenient behaviors. In low-cost situations, environmental concern should no longer be the dominant predictor of ecological behavior, as even the less concerned are likelier to dispose of household waste in a socially acceptable way, that is, by recycling (see Figure 1, gray arrow).

Taking into account the informal support of social norms, our argument implies that environmental concern ceases to impact recycling behavior in low-cost situations. This prediction mirrors the "ABC theory" (Guagnano et al., 1995), which assumes that intrinsic motivation for environmental protection (A) no longer determines environmental behavior (B) if extrinsic context (C)—such as the availability of low-cost recycling facilities and social norms supporting their use—makes choosing a pro-environmental behavior increasingly self-evident: "If behavior is . . . so easy to do that everyone's attitude is strong enough, variations in *A* will have no predictive value for *B*" (Guagnano et al., 1995, p. 703). Schultz and Oskamp (1996) posit a similar "effort hypothesis" according to which attitudes predict behavior only under increased costs.

We further argue that a social-norm regime leads people with strong attitudes toward environmental protection to persevere despite rises in recycling costs. Individuals complying not only with social expectations but also with personal convictions should be more willing to compensate for increased costs of pro-environmental behavior. We thus expect that, under a social-norm regime, effort is less relevant for individuals holding corresponding attitudes (see Figure 1, black arrow). Hence, for recycling strongly supported by social norms, we expect:

> **Hypothesis 4:** Environmental concern determines recycling participation only as effort increases.

Several theoretical arguments and empirical findings about norm compliance provide a rationale for this interaction hypothesis in situations strongly governed by social norms. First, the regulatory influence of social norms increases when these accord with personal attitudes (Festinger, 1957; Schwartz, 1977). Second, adherence to social expectations may reassure environmentally concerned individuals of their identity, whereas not recycling could jeopardize a favorable self-image (Akerlof & Kranton, 2000; Steele, 1988) and deplete intrinsic utility from conformity to personal convictions (Andreoni, 1990; Opp, 2013). Third, dual-process and framing theories suggest that situational cues (e.g., others' observed recycling participation) define mental representations of a situation and thus lead to those behavioral choices deemed appropriate (Chaiken & Trope, 1999; Lindenberg & Steg, 2007). A popular formulation distinguishes a deliberative mode of cost–benefit calculation from an automatic-spontaneous mode more strongly patterned by moral obligations (Best & Kneip, 2011; Kroneberg, Yaish, & Stocké, 2010). The latter frame's activation—which pushes incentive-based reasoning to the background—becomes more likely for the highly concerned as situational cues match their personal convictions.

Testing our hypotheses requires household-level data on recycling participation, $Y = \{0,1\}$, recycling costs C, and environmental concern A. To assess the relevance of C, A, and the interaction $C \times A$ for environmentally friendly behavior of each household i, we estimate binary logistic regressions on the probability of recycling participation:

$$\log\left(\frac{Pr(Y_i = 1)}{1 - Pr(Y_i = 1)}\right) = \beta_0 + \beta_1 C_i + \beta_2 A_i + \beta_3 (C_i \times A_i) \quad (1)$$

Our theoretical expectations, first, imply $\beta_1 < 0$ (Hypothesis 1) and $\beta_2 > 0$ (Hypothesis 2). Our conjecture that social norms moderate the LCH's tenability in recycling research then suggests a simple test strategy: Because descriptive norms depend on prevalence, strong normative support should only target frequently recycled waste categories. We therefore differentiate the recycling of plastics and glass. Recycling plastics is an uncommon disposal strategy, with less than 50% of respondents reporting full participation such that social norms enforcing participation should be correspondingly weak. Recycling glass, on the other hand, has evolved in Munich into a normal disposal strategy, with more than 80% of respondents stating they fully participate. Our test procedure compares the parameters from Equation (1), estimated separately for each waste category, with the expectation that $\beta_3 < 0$ (Hypothesis 3) holds for the recycling of plastics, but $\beta_3 > 0$ (Hypothesis 4) for the recycling of glass. In other words, we hypothesize that the LCH's scope conditions have narrowed down to include only environmental behavior for which compliance-enforcing social norms are weak.

Method

Study Context

In Munich, a city of 1.5 million inhabitants in southern Germany, waste collection is fully standardized. On one hand, a city-wide curbside system exists for residual waste, paper, and organic waste. On the other, residents are expected to dispose of plastics, glass, and metal at communal collection sites situated in each neighborhood (Munich Waste Management, 2016). Each collection site offers separate containers for all three recyclables. Participation in this recycling regime is relatively high, although inappropriate disposal of recyclable materials in residential residual waste bins is not legally sanctioned.

We base our study on residents' unintentional assignment to differential recycling costs due to differing walking distances between each household and its nearest collection site. We can interpret this naturally occurring exogenous variation as an "as-if" random assignment of subjects into different "treatment conditions" without direct intervention. If one can plausibly reject systematic associations between treatment assignment and the response variable (i.e., balanced study groups), such study contexts resemble a natural experiment. Behavioral data generated from natural experiments conform to the framework of potential outcomes (Rubin, 2005) and thus to a manipulationist notion of causal inference (Woodward, 2005). Properly conducted, natural experiments transpose the rigor of experimental designs into the realm of observational data and—in contrast to quasi-experiments or correlational analyses lacking exogenous treatment assignment—permit causal interpretation (Achen, 1986; Angrist & Pischke, 2008). Consequently, social scientists interested in causal inference apply such designs in research settings defying randomized intervention due to practical or ethical limitations (e.g., Dunning, 2012; Shadish, Cook, & Campbell, 2002).

We combine this natural experiment with survey data on residents' self-reported recycling behavior and environmental concern ($N = 754$). We further complement our data with an independent online survey on the local intensity of social norms for the recycling of different waste categories ($N = 640$).

Participants

We conducted a paper-and-pencil survey in March 2012 to collect residents' geographic locations as well as their self-reported recycling behavior, level of environmental concern, and sociodemographics. We dubbed the survey "Munich environmental study" and informed participants about our aim to gather data on environmental attitudes and behavior.

Our survey area comprises seven city districts spanning from the urban center to the southern outskirts of Munich (see the shaded area in Figure 2, left panel). The selected area maximizes sample heterogeneity with respect to sociodemographic composition, population density, building types, and land use. Consequently, our survey area includes both crowded inner-city (e.g., Ludwigsvorstadt, Isarvorstadt) as well as suburban neighborhoods (e.g., Harlaching, Forstenried), more affluent (e.g., Solln) and also low-income neighborhoods (e.g., Giesing), and districts with low (e.g., Au-Haidhausen) and high average age (e.g., Ramersdorf-Perlach). We chose these differences

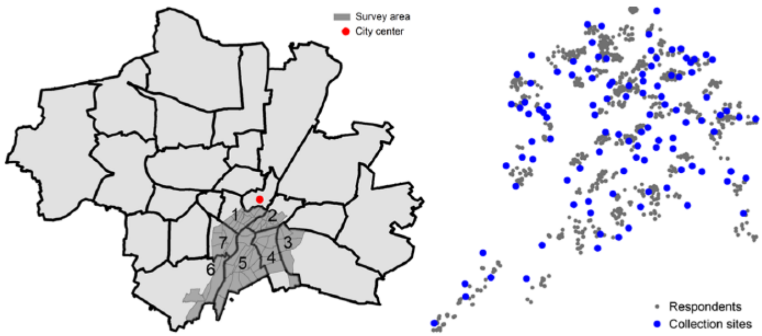

Figure 2. Survey area and respondent and drop-off site locations.
Note: 1 Ludwigsvorstadt-Isarvorstadt (178 respondents), 2 Au-Haidhausen (143), 3 Ramersdorf-Perlach (94), 4 Obergiesing-Fasangarten (104), 5 Untergiesing-Harlaching (249), 6 Thalkirchen-Obersendling-Forstenried-Fürstenried-Solln (68), 7 Sendling (71).

in composition to increase the generalizability of our results across various urban environments.

Within the survey area, we sampled the postal addresses of 3,300 households using a random-route procedure, and mailed each sampled household our questionnaire (and a prepaid return envelope).[4] One week after the original distribution, we sent all households a reminder. A gross sample of 1,057 respondents (32% response rate) resulted from these measures. Our net sample is comprised of 754 respondents who provided complete information on recycling behavior, environmental concern, and sociodemographic background.

Comparisons to official data (Munich Statistics Agency, 2012) reveal a bias in our net sample toward women (56% rather than 51%) and German-born residents (95% rather than 75%). This lack of representativeness does aggravate descriptive explorations but does not further complicate our causal analysis.

To validate our presumption that social norms govern the recycling of plastics and glass with different intensities, we conducted an independent online survey among Munich students. We sent a short questionnaire to 1,602 students who had previously enlisted to participate in online surveys. Data collection took place in December 2016 and, following a timely reminder, resulted in 640 completed interviews (40% response rate). Mirroring the composition of the local student pool, our sample is 70% female and 86% German.

Measures

Geographical distance. In extension to studies utilizing the introduction of curbside collection (e.g., Best & Kneip, 2011; Derksen & Gartrell, 1993; Guagnano et al., 1995), we draw on a continuous measure of recycling effort. First, we identified 158 recycling containers within or nearby our survey area from an official list of collection sites in Munich, and retained their geocodes (i.e., each site's latitude and longitude) using Google Maps' satellite imagery. Second, we obtained residents' geocodes by matching incoming questionnaires with respondents' original mail addresses. To do so, we assigned each questionnaire an identification number. To protect respondents' anonymity, we always gave questionnaires sent to two adjacent addresses the same identifier. This resulted in 3,300 / 2 = 1,650 identifiers, followed by a random assignment of each incoming questionnaire to one of two possible household addresses. Consequently, one-to-one matching of responses to addresses is impossible while imprecision in geocoding remains small and errors are random. Third, we computed each respondent's walking distance to the 158 collection sites using Stata's geocode and traveltime commands (Ozimek & Miles, 2011) and identified the closest drop-off recycling container for each household. Based on this operationalization, we defined 51 collection sites as out of reach for the sample population, reducing the set of destinations to 107 collection sites. The right panel in Figure 2 shows the locations of both our respondents and their relevant collection sites. We use each household's walking distance to the nearest container as our continuous indicator of recycling costs. The left panel in Figure 3 displays its distribution; the shortest distances range from 0.01 to 0.75 km, and the mean (median) distance is 0.29 (0.26) km.

Environmental concern. We adopted our measure of environmental concern from Diekmann and Preisendörfer (2003). Their index consists of nine items capturing affective, cognitive, and conative aspects of ecological awareness on a 5-point Likert-type scale (see the online appendix for items and descriptive measures). The index is widely used in the literature, including Best's and Kneip's (2011) field experiment. The index ranges from 1 (*no concern*) to 5 (*strong concern*). Reliability is high, with Cronbach's $\alpha = .832$. The sample mean (median) is 3.77 (3.78). The right panel in Figure 3 displays its distribution. Diekmann and Preisendörfer (2003) report a sample mean of 3.28 (rescaled to our range of 1-5) for their survey data collected in 1996. A one-sample t-test discloses their mean as significantly lower than ours in contemporary data ($t = 20.37$, $p < .001$).

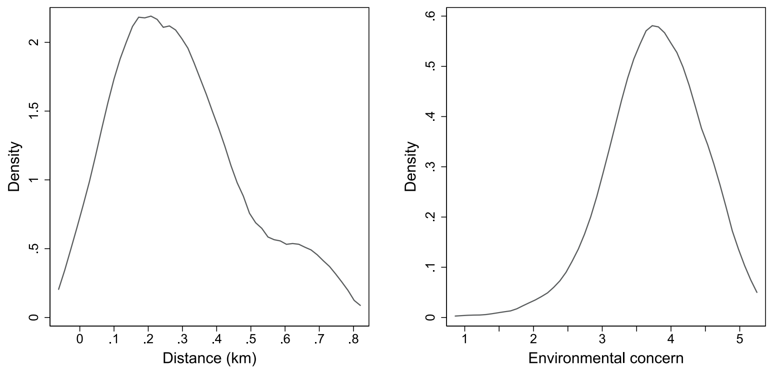

Figure 3. Distribution of recycling costs and environmental concern.

Sociodemographics. We collected a wide range of individual and household characteristics (see Table 1 for a description). Conditioning on these variables can both refine our measures of attitudes and recycling effort as well as foster the balancing of study groups across walking distances to the nearest drop-off container (see "Procedure"). Binary measures of gender (1 = *male*), health (1 = *poor health*), and car use for shopping or commuting (1 = *frequently*) belong to the first group of characteristics: Female participants reported stronger ecological attitudes (mean environmental concern is 3.89 for females and 3.61 for males; $t = 5.81$, $p < .001$). We control for gender to avoid confusing gender effects in response behavior with household differences in environmental concern. Further, health constraints may deter some respondents from walking to the nearest collection site even if they wish to recycle. Frequent car use, on the other hand, renders walking distances unimportant for some households, such that our cost variable does not necessarily apply. We introduce a second group of controls to improve the balancing of environmental concern across treatment levels of walking distance. Respondents with higher age (measured in decades), higher education (1 = *high school degree or above*), and higher household income (log.), as well as larger households (log.) and home owners (1 = *home ownership*) tend to live farther from inner-city neighborhoods and thus to have slightly larger average walking distances to their nearest collection sites.[5] The opposite applies to households in larger apartment buildings, which often have recycling containers in their immediate proximity. The number of tenants living in the same building (and consequently using the same collective residual waste bin) also indicates whether nonparticipation in recycling is traceable back to individuals. Hence, this variable provides a valuable touchstone for our

Table 1. Description of Key Variables and Controls.

	Plastics (*N* = 701)			Glass (*N* = 754)		
Variable	Minimum	Maximum	*M* (*SD*)	Minimum	Maximum	*M* (*SD*)
Distance (km)	0	0.75	0.28 (0.18)	0	0.75	0.29 (0.18)
Environmental concern	1.11	5.00	3.77 (0.66)	1.11	5.00	3.77 (0.66)
Male	0	1	0.44	0	1	.44
Poor health	0	1	0.12	0	1	.13
Car use	0	1	0.34	0	1	.36
Age/10	1.80	9.50	4.81 (1.69)	1.80	9.50	4.85 (1.70)
Higher education	0	1	0.68	0	1	.67
log Household income	5.39	10.17	7.88 (0.61)	5.39	10.17	7.88 (0.61)
log Household size	0	2.20	0.55 (0.48)	0	2.20	0.55 (0.48)
Home ownership	0	1	0.22	0	1	.22
Log no. tenants	0	5.70	2.50 (0.78)	0	5.70	2.49 (0.78)

social-norms argument: We expect the (log.) number of tenants to associate negatively with the probability of glass recycling. For plastics—for which social norms are weaker and nonparticipation is more widespread—this variable should be irrelevant.

Recycling behavior. We focus on the recycling of plastics and of glass, in which Munich residents engage with different intensities.[6] We collected household participation data for recycling of each waste category on a 3-point scale: always, occasionally, and never (see Table 2). Following the operationalization by Diekmann and Preisendörfer (2003) and Best and Kneip (2011), we dichotomized both scales (0 = *never* or *occasionally*, 1 = *always*) into two binary dependent variables measuring full recycling participation. As we encounter more missing values for the plastics variable, we use two separate samples with $N = 701$ for plastics and $N = 754$ for glass, respectively. Across waste categories, clear differences are evident in the relative frequencies of recycling participation. Recycling glass appears to be a normal disposal strategy with 81.7% of respondents stating full participation. Recycling plastics, on the other hand, is much less common. The rate of full participation is 47.7%. A cross-tabulation shows that participation in recycling correlates across waste categories ($\chi^2 = 156.70$, $p < .001$). Of those who always recycle glass, however, only 56.8% report always recycling plastics.

Table 2. Frequency of Recycling.

	Plastics		Glass	
	N	%	*N*	%
"Always"	335	47.79	616	81.70
"Occasionally"	123	17.55	69	9.15
"Never"	243	34.66	69	9.15
Total	701	100.00	754	100.00

Intensity of social norms. We measure norm strength in an independent sample of Munich students. Following Ajzen's (2006) manual on measuring perceived norms, we first capture injunctive aspects with the item "To what extent do you agree with the following statements? Most people find it very important to dispose of plastics (glass) separately from residual waste," which participants could rate on a 7-point scale ranging from *do not agree at all* to *totally agree*. On average, students perceived others' normative expectations as to recycling to be substantially stronger with regard to glass (5.20) than to plastics (4.13). This difference is significant ($t = 15.62$, $p < .001$). To cover descriptive aspects, we asked participants to estimate the fraction of Munich households who *always*, *occasionally*, or *never* recycle plastics and glass. Students offered diverging estimates for others' full participation in the recycling of plastics (27.6%) and of glass (44.1%). This difference too is significant ($t = 18.39$, $p < .001$).[7]

Procedure

Our study takes advantage of the exogenous assignment of urban residents to individual recycling costs, focusing on the variation in spatial distances to the nearest recycling container for a cross-section of residents (see Figure 2). Lacking an actual randomization device, we rely on as-if random assignment of participants to walking distances. Establishing plausible as-if randomization—and thus statistical independence between potential confounders and treatment levels—in natural experiments relies on both qualitative information and quantitative tests (Dunning, 2012, chaps. 7, 8).

In our study context, the assumption of as-if random treatment assignment is persuasive in that one may expect urban dwellers will select residences due to market availability and budget constraints rather than individual recycling preferences. This holds particularly in Munich's tight housing market, with rental and real-estate prices considerably higher than in the rest of Germany.[8]

The vacancy rate of Munich residences has been estimated to be 0.2% (Spiegel Online, 2016). While residents may have the information and capacity to self-select into treatment levels, they lack an incentive for doing so. Instead, as *Süddeutsche Zeitung* (2016), a local newspaper, reports, "inhabitants of Munich have difficulties finding housing . . . Consequently, they take whatever residence they can get hold of, typically at excessively high prices." In other words, it is highly unlikely that residents will have turned down housing offers due to long distances between the potential residence and the nearest recycling collection site.

Our design requires that we dismiss self-selection of environmentally concerned households into residences with shorter walking distances to the nearest recycling container. Only if balancing of study groups is satisfactory will simple comparisons across continuous treatment levels suffice to test our hypotheses. Biased balancing, on the other hand, requires statistical control for observed confounders.

In Figure 4, we quantitatively assess the quality of respondents' as-if randomization to recycling costs. For a nonparametric balancing test, we split the distance variable into 50 m intervals to compare respondents' average environmental concern across bins. We find small and nonsignificant differences across intervals ($F = 0.87$, $p = .565$). As indicated by $\eta^2 = .013$, categorized distance explains less than 1.5% of the variance in environmental attitudes. In a linear specification (see Table 3, Model 1) this pattern amounts to $\beta = -0.197$ ($p = .141$). The total effect—which indicates the unit change of average concern by moving from 0 to the maximum of the distance variable—is $-0.197 \times 0.75 = -0.148$. Although nonsignificant, variation in recycling costs is not fully exogenous to environmental concern, reflecting compositional differences across residential neighborhoods. In Model 2 in Table 3, we control for the sociodemographic variables introduced above. Conditioning reduces the unwanted association to $\beta = -0.097$ ($p = .468$) so that the total effect amounts to -0.073. Our formal test demonstrates that, under conditioning, population means across different treatment levels are equal as to environmental concern and thus unaffected by treatment assignment. To "unbias" balancing across study groups, our models will include composition controls.

Our test strategy then entails estimating the logit Equation (1) separately for plastics and glass recycling. We center both the walking distance to the nearest recycling container and environmental concern to yield meaningful main effects of both interacted variables (Hypotheses 1 and 2). In doing so, each point estimate quantifies the main effect conditional on the other variable's mean (rather than the value of 0).

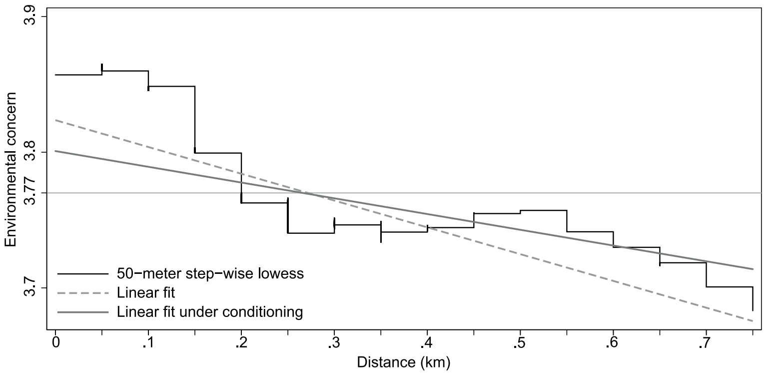

Figure 4. Balancing of environmental concern.
Note. The horizontal line indicates the total sample mean of environmental concern (3.77). Linear fits refer to Models 1 and 2 in Table 3.

Table 3. Linear Balancing Test.

	Environmental concern			
	1		2	
	β	*SE*	β	*SE*
Distance	−0.197	(0.134)	−0.097	(0.134)
Male			−0.257***	(0.048)
Poor health			0.084	(0.078)
Car use			−0.198***	(0.050)
Age/10			−0.004	(0.017)
Higher education			−0.006	(0.056)
Log household income			−0.049	(0.045)
Income data missing			−0.062	(0.091)
Log household size			0.159**	(0.054)
Home ownership			−0.058	(0.059)
Log no. tenants			−0.007	(0.030)
Constant	3.824***	(0.046)	4.314***	(0.366)
N	754		754	
R^2	.003		.081	
Adjusted R^2	.002		.068	

Note. OLS regressions. Standard errors in parentheses.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Our theorizing further suggests testing the conditional effect of respondents' environmental concern at different levels of recycling effort while holding potential confounders constant. Technically speaking, we are interested in comparing effect heterogeneity of environmental concern with regard to walking distances for both plastics and glass recycling. Estimates of interaction effects in logistic regressions, however, depend on the values of covariates. A direct evaluation of interaction effects "simply by looking at the sign, magnitude, or statistical significance of the coefficient on the interaction term" (Ai & Norton, 2003, p. 129) is not possible within the framework of logistic regression.

Our interpretations with regard to the crucial Hypotheses 3 and 4 will therefore rely on graphical representations of our estimates. Plotting average marginal effects (AMEs) of environmental concern on plastics and glass recycling for different walking distances provides a straightforward solution. The plots demonstrate for which values of distance the contrasts between people with high and low environmental concern are significant. AMEs are comparable across both models and samples (Mood, 2010) and, in contrast to other logistic regression estimates, permit an intuitive interpretation: Each point estimate resembles the percentage-point change in recycling participation due to a unit increase in the independent variable.

Our final models will include sociodemographic covariates as well as district-level fixed effects to prevent unobserved heterogeneity across neighborhoods from biasing our results. Taking into account the multilevel structure of our data with households nested in seven city districts (see Figure 2), the latter models will provide our most valid estimates. Among other things, our fixed-effects models condition on district-level differences in the number of available collection sites and control for unobserved disparities in population composition across districts.

Results

Our analysis aims at testing the conditional effect of respondents' environmental concern (dependent on recycling effort) on households' probability of recycling participation both outside and within a social-norm regime. We find support for our hypotheses: (a) Higher effort reduces the probability of recycling, while (b) higher environmental concern increases the probability of recycling. In line with our theoretical expectations on the tenability of the LCH, we find that (c) the LCH explains participation in the recycling of plastics but (d) does not hold for the socially expected recycling of glass.

Table 4 summarizes our results. Models 1 and 4 relate directly to Equation (1) and show the main effects of recycling effort and environmental concern

Table 4. Determinants of recycling.

	Plastics (*N* = 701)					
	1		2		3	
	β	*SE*	β	*SE*	β	*SE*
Distance	−18.04	(10.59)	−27.42**	(10.58)	−20.87†	(10.86)
Environmental concern	9.69***	(2.83)	8.67**	(2.86)	8.93**	(2.84)
Distance × Concern	−9.91	(16.97)	−6.27	(16.29)	−7.59	(16.21)
Male			−0.62	(3.89)	−0.34	(3.88)
Poor health			−5.72	(6.11)	−6.38	(6.11)
Car use			−6.07	(3.98)	−6.99†	(4.08)
Age/10			7.15***	(1.30)	7.40***	(1.31)
Higher education			5.26	(4.50)	5.85	(4.55)
Log household income			−3.59	(3.54)	−3.44	(3.56)
Income data missing			−5.17	(7.72)	−5.50	(7.68)
Log household size			10.93*	(4.23)	10.80*	(4.23)
Home ownership			5.73	(4.60)	4.81	(4.66)
Log no. tenants			0.07	(2.40)	0.23	(2.40)
District fixed effects	No		No		Yes	
	Glass (*N* = 754)					
	4		5		6	
	β	*SE*	β	*SE*	β	*SE*
Distance	−22.83**	(7.47)	−27.01***	(7.36)	−25.96**	(7.62)
Environmental concern	5.43**	(2.08)	4.66*	(2.12)	4.85*	(2.10)
Distance × Concern	4.43	(11.62)	8.18	(11.39)	11.19	(11.62)
Male			−3.50	(2.88)	−3.38	(2.86)
Poor health			−5.08	(4.11)	−5.97	(4.09)
Car use			−5.45†	(2.90)	−5.54†	(2.94)
Age/10			1.77†	(0.98)	1.87†	(1.00)
Higher education			13.54***	(3.05)	14.17***	(3.11)
Log household income			4.66†	(2.65)	4.76†	(2.63)
Income data missing			−2.65	(4.81)	−2.65	(4.79)
Log household size			8.11*	(3.25)	7.70*	(3.19)
Home ownership			2.68	(3.47)	3.68	(3.54)
Log no. tenants			−3.63*	(1.67)	−4.05*	(1.67)
District fixed effects	No		No		Yes	

Note. Logistic regressions. Average marginal effects (AME) × 100 reported. Standard errors in parentheses.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

as well as their interaction on the probability of participation in the recycling of plastics and glass, respectively. Models 2 and 5 include a vector of covariates either refining our measures of attitudes and effort (gender, health, car use) or fostering the balancing across treatment levels (age, education, (log.) household income, household size, home ownership, and the (log.) number of tenants). Our final Models 3 and 6 further include district-level fixed effects to prevent unobserved heterogeneity across neighborhoods from biasing our results.

In support of Hypothesis 1, the main effect of behavioral costs on recycling participation is significantly negative across the various model specifications. Focusing on our fixed-effects specifications (Models 3 and 6), a one-unit increase in walking distance (+1 km) reduces the predicted probability of recycling by roughly 21 percentage points for plastics ($p = .055$) and 26 percentage points for glass ($p = .001$). Total effects, again indicating changes in recycling probabilities due to moving from 0 to the maximum value of 0.75 km in the distance variable, amount to $-20.87 \times 0.75 = -15.65$ and $-25.96 \times 0.75 = -19.47$ percentage points, respectively. Finding a negative effect of recycling effort is consistent with the notion that individuals more readily adhere to environmentally friendly behavior when the inconvenience of doing so is small.

In support of Hypothesis 2, the main effect of environmental concern on recycling is significantly positive, indicating that the probability of choosing pro-environmental behavior increases with positive ecological attitudes. Again focusing on Models 3 and 6, increasing environmental concern (1-5) by one point relates to 8.93 ($p = .002$) and 4.85 ($p = .021$) percentage-point increases in recycling probabilities for plastics and glass, respectively. This positive attitude effect demonstrates that individuals with higher levels of environmental concern exhibit more ecologically sound behavior when it comes to recycling.

To test Hypotheses 3 and 4, we graphically assess the interplay of environmental concern and behavioral costs in bringing about recycling behavior in a manner analogous to Figure 1. Therefore, we predict the probability of plastics and glass recycling for different walking distances based on the estimates obtained in Models 2, 3 and 5, 6, respectively (Figure 5a and 5c). Our conditional profile plots display separate lines for respondents stating either high (90% percentile in the attitude variable) or low environmental concern (10% percentile). In addition, we present conditional effect plots illustrating how the AME of environmental concern on recycling probabilities changes with increasing recycling effort (Figure 5b and 5d). The latter plots contrast the impact of attitudes on pro-environmental behavior for respondents with high

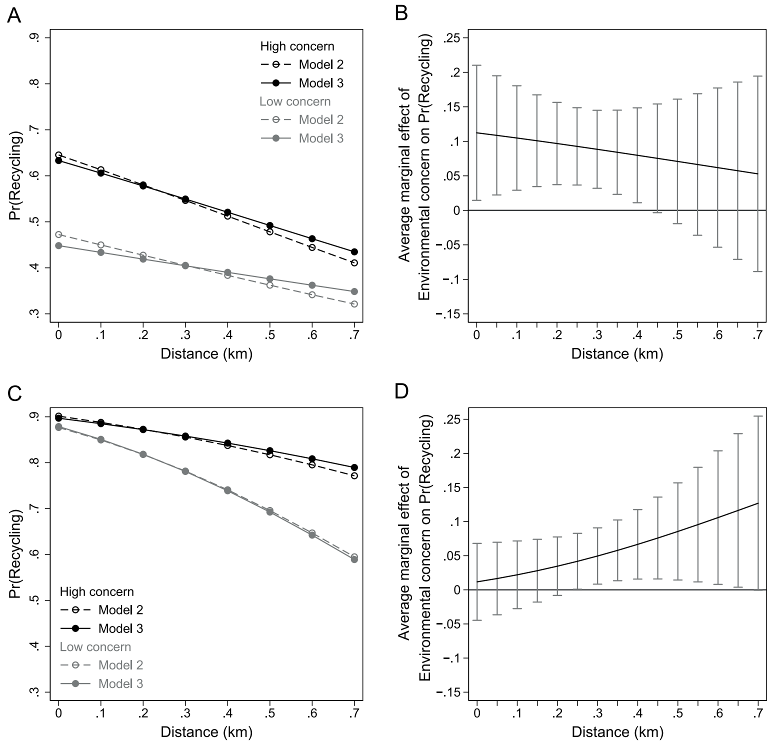

Figure 5. Probabilities of recycling.
Note. Left panels (a) and (c): Predicted probabilities of "always" recycling differentiated by respondents' environmental concern. Low (high) concern: 10% (90%) percentile. Predictions are based on the models displayed in Table 4. Right panels (b) and (d): Effect plots with 95% confidence intervals based on Models 3 (plastics) and 6 (glass) in Table 4.

or low environmental concern. For statistical inference, we include 95% confidence intervals.

In support of Hypothesis 3, we encounter associations closely resembling the classical predictions of the LCH for the recycling of plastics, where social norms enforcing participation are weak: The probability of recycling most strongly diverges between the more and less environmentally concerned under low-cost conditions (Figure 5a). Respondents with strong attitudes toward environmental protection, however, become less inclined to recycle as effort increases, and hence behaviors in both groups converge with increasing effort. Consequently, environmental concern ceases to impact recycling behavior as distance to the nearest drop-off container rises (Figure 5b). Comparing households with high or low concern reveals substantial and significant differences in the probability of recycling for distances below 0.45 km. This negative interaction effect corroborates the idea that individuals comply with personal convictions more readily when environmentally friendly behavior requires little effort.

In support of Hypothesis 4, results differ for the "normal" behavior of recycling glass, for which social norms strongly enforce participation. In low-cost conditions, the probability of recycling is almost identical for the environmentally concerned and the less concerned, whereby the former exhibit remarkable resistance to rising costs (Figure 5c). Consequently, the impact of environmental concern increases with distance (Figure 5d), and the contrast between groups is significant for distances beyond 0.20 km.[9] This positive interaction effect is consistent with our theorizing that, on the one hand, social costs of nonparticipation encourage recycling among the less concerned and that, on the other, respondents complying not only with social expectations but also with their own personal convictions can more easily compensate for increasing costs of pro-environmental behavior. Recycling behavior under a social-norm regime thus slips out of the LCH's scope.[10]

Regarding our controls, we observe the expected results (although most coefficients are nonsignificant): A tendency toward nonparticipation in recycling is apparent among men as well as among both the sick and frequent car drivers. Higher age, higher education, and home ownership associate with increased probabilities of recycling. Larger households seem to coalesce a sufficient number of helping hands to make recycling attractive—a side-finding that one may interpret as a consequence of economies of scale. Most importantly for our argumentation, however, is that the (log.) number of tenants yields a significant negative correlation with the probability of glass recycling (AME × 100 = 4.05; $p = .015$), whereas we observe no such association for plastics recycling (AME × 100 = 0.23; $p = .924$). The possibility of tracing recycling behavior back to a specific household has thus a profound impact on recycling participation under a social-norm regime but appears to be irrelevant for the recycling of a waste category lacking social sanctions (we find a similar yet less pronounced pattern associating household income with recycling across waste categories). This finding is in line with the descriptive information generated from our student survey and corroborates the notion that social norms governing glass recycling are stronger and more widespread than those in support of plastics recycling.

Discussion

Proponents of the "low-cost hypothesis" (LCH) argue that attitudes explain behavior only if complying with personal convictions requires little effort (Diekmann & Preisendörfer, 2003). Evidence for the LCH, however, remains inconclusive and, for the case of household waste recycling, the most recent studies in particular have reported opposing results (e.g., Best & Kneip, 2011; Kaiser & Schultz, 2009).

We contribute to this debate with an attempt to reconcile these seemingly contradictory findings. We argue that, since the collection of most of the data in line with the LCH during the 1980s and 1990s, recycling has developed into a normal behavior (Thomas & Sharp, 2013) increasingly influenced by social norms (Bicchieri, 2006; Cialdini, 2007). We theorize that constraints of social rules have altered the trade-off between environmentally friendly and more convenient behaviors such that, in low-cost situations, even the environmentally unconcerned dispose of household waste following social standards. At the same time, several theoretical claims about human behavior in the face of social norms (e.g., Akerlof & Kranton, 2000; Andreoni, 1990; Lindenberg & Steg, 2007) suggest that individuals with strong attitudes toward environmental protection became more resistant to higher recycling costs.

Our data combined a natural experiment exploiting exogenous variation in walking distances to the nearest drop-off recycling sites with self-reported information on environmental concern and recycling participation ($N = 754$). Differentiating the recycling of two distinct waste categories, plastics and glass, enabled a simple test strategy for assessing the LCH's tenability for contemporary recycling research: As normative expectations depend on prevalence, strong normative support should apply only to frequently recycled waste categories. Recycling glass appeared as a normal disposal strategy, with more than 80% of respondents reporting full participation, whereas recycling plastics is much less common in Munich (50%) and social norms enforcing participation are weaker. We validated the diverging strength of local recycling norms in an independent online survey ($N = 640$), which revealed substantially (and significantly) stronger normative support for participation in recycling glass.

In support for our hypotheses, our data revealed that (a) greater effort reduces the probability of recycling, while (b) higher environmental concern increases that probability. In line with our theoretical expectations on the tenability of the LCH, we find that (c) the LCH explains participation in the recycling of plastics but (d) does not hold for the socially expected recycling of glass. Rather than discarding the LCH altogether, our results imply that its scope has narrowed down to include only environmental behaviors for which social norms are weak, for which behavioral trade-offs remain intact. Our model specifications take into account compositional differences across city districts and thus render our findings generalizable across various urban environments. Generalizing beyond our specific application, these findings suggest that the LCH does not apply in situations in which social norms dominate the behavioral influence of personal attitudes. In this sense, social norms serve as a boundary condition for the LCH's validity.

Although meticulous design was our highest priority, some methodological drawbacks remain. First, we measured recycling behavior on the household level, whereas environmental concern refers to individual respondents. We addressed within-household measurement error by adding individual-level controls including gender, age, health, and education. In addition, we believe that both homophily in household formation and socialization within families (McPherson, Smith-Lovin, & Cook, 2001) considerably limit the variation of environmental attitudes and behavior within our units of observation.

Second, we relied on self-reported recycling behavior, which may not fully capture actual recycling participation but exhibit bias toward socially desirable behavior (Huffman, van der Werff, Henning, & Watrous-Rodriguez, 2014). Although such a bias would surely increase the consistency of attitudes and behavior, we agree with Diekmann and Preisendörfer (2003) that potential bias does not affect our conclusions in that our focus lies on contrasting the association of attitudes and behavior across different levels of behavioral costs. Similar reasoning applies to our disclosing of the paper-and-pencil survey's aim to potential participants. Gathering participants' informed consent is both good practice in social science research and a requirement for our funding partners. This practice may strengthen self-selection into participation and/or bias self-reported behaviors and attitudes, but, again, we are interested not primarily in the levels of both environmental concern and recycling participation but in the moderation of their association by recycling effort.

Third, failing to collect local intensities of recycling norms in our original survey is a shortcoming of our design. Our efforts to compensate for this weakness rest on an independent sample of Munich students. Our follow-up study puts greater weight on shutting-off consistency effects. Consistency bias (e.g., Falk & Zimmermann, 2012) might arise if respondents simultaneously report their own behaviors as well as their perceptions of these behaviors' social importance. Ideally, however, we would have randomized our original survey population to self-report either their attitudes and recycling participation or their beliefs on the strength of injunctive and descriptive norms of recycling. In support of our follow-up, reported rates of recycling are very similar between students and the general population (see Note 7), providing some indication that an ordinal ranking of perceived norm strength for plastics and glass should not differ across both samples.

Fourth, some have proposed that finding support for the LCH becomes increasingly difficult as population variability in attitudes and behavior decreases such that "virtually everyone is favorable or almost everyone engages in a particular behavior" (Kaiser & Schultz, 2009, p. 189). This threat to internal validity could, theoretically, apply to highly prevalent glass recycling, but our data speak against this interpretation as the correlation between environmental concern and recycling does not simply deflate across the whole range of walking distances but increases substantively with rising recycling effort (cf., Figure 5d). Hence, rather than disclosing a zero effect under a social-norm regime, our analysis indicates the exact opposite of what the LCH would have predicted.

Having said this, we believe our continuous cost measure enables a fairer test of the LCH than studies scrutinizing the introduction of curbside collection (e.g., Best & Kneip, 2011; Derksen & Gartrell, 1993; Guagnano et al., 1995) have provided. The latter design exploits sharp reductions in recycling effort such that—in the discrete treatment condition—the cost of separate disposal of recyclable waste approaches zero and so more and more households recycle regardless of personal conviction. On one hand, this implies mechanisms guiding recycling behavior as described in Guagnano and colleagues' (1995) "ABC theory": If external conditions make pro-environmental behaviors increasingly natural, intrinsic motivations for environmental protection will no longer determine the choice to participate in recycling. Focusing on heterogeneous costs within a stable drop-off regime, we explicitly excluded that scenario from our respondents' decision space, leaving intact the original trade-off between pro-environmental behavior and less costly alternatives.

On the other hand, we must keep in mind that implementations of curbside collection sharply increase recycling participation across relevant waste categories. In Best's and Kneip's (2011) study, for example, participation in plastics recycling increased by almost 20 percentage points to 70% after the introduction of curbside collection. In the wake of such prevalence shifts, however, changes in normative support for recycling appear likely and might include observed compliance by neighbors (descriptive norm) as well as updating perceived normative expectations (injunctive norm), and thus a "normalization" of waste recycling. Such concomitant phenomena rule out the possibility of empirically disentangling the effects of changing costs and tightened normative constraints. Our alternative methodology instead permits direct inclusion of social norms as a moderator of attitude–behavior relations.

Our results clearly demonstrate a greater willingness to participate in recycling under conditions of heightened normative support. Social norms for appropriate household waste disposal not only increase the likelihood of recycling but also promote additional effects on pro-environmental behavior if social visibility permits tracing of individual disposal strategies. Normative appeals might further add to environmental awareness and thus activate households currently hesitant to participate fully in recycling (see, particularly, Bolderdijk, Steg, Geller, Lehman, & Postmes, 2012). Minimizing the effort of recycling, on the other hand, will surely support participation and, as Steg et al. (2014) say, "facilitate individuals to act upon their normative considerations" (p. 110).

Going beyond these general conclusions, our study offers refined policy implications for urban waste management: If informal support for recycling has been established, normative appeals will affect participation particularly under conditions of increased effort. Under such high-cost conditions, individual attitudes are key to understanding recycling participation. Hence, under a social-norm regime, the opportunity to strengthen compliance through normative appeals offers favorable conditions for economizing public waste collection. In cases of weak informal support, however, normative appeals to voluntary contribution will be most effective in low-cost situations. Here, personal attitudes have the greatest explanatory power for recycling participation. If local authorities fail to provide convenient recycling schemes, however, communities will be unable to compensate with relatively inexpensive "Hearts and Minds" campaigns.

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Notes

1. We adopt the term *behavioral costs* from Diekmann and Preisendörfer (2003) to describe the effort associated with certain behaviors. "Costs," in this sense, are not restricted to monetary expenses but accrue for all behaviors that are "difficult, expensive, or inconvenient for most members of the population" (Guagnano, Stern, & Dietz, 1995, p. 702; see also, for example, Ostrom, 1998, for a broader usage of the term). In our analyses, we operationalize behavioral costs by the effort it takes to choose the environmentally friendly behavior. We thus use both terms, *costs* and *effort*, interchangeably.
2. Social norms are informal rules prescribing ("thou shalt") or proscribing ("thou shalt not") certain behaviors. If perceived valid among a sufficient fraction of the population and thus supported by mutual expectations of compliance, emerging social norms generate and alter established behavior patterns (Bicchieri, 2006; Bicchieri & Xiao, 2009).
3. More recent meta-analyses support positive average treatment effects of peer comparison on household waste recycling, energy and water conservation, and towel reuse (Abrahamse & Steg, 2013; Delmas, Fischlein, & Asensio, 2013; Scheibenehenne, Jamil, & Wagenmakers, 2016), although comparative feedback remains less effective than more expensive interventions such as face-to-face audits and personalized consulting.
4. Starting from 58 randomly drawn street corners, we sampled every fourth private household. Random-route instructions are available on request. To avoid sampling bias within households, we asked each household member (≥18 years) who last celebrated her or his birthday to fill out the questionnaire.
5. Regarding household income, 54 respondents (7.2% of our net sample) refused to provide information. Instead of dropping these cases, we introduce a binary variable with value 1 for respondents with missing income data. Item-nonresponse correlates negatively with both environmental concern (see Table 3) and recycling (see Table 4). These associations, however, are nonsignificant and dropping these cases does not alter our results. Another potential confounder could be the length of residence in a particular neighborhood. Length of residence has been found to be linked to feelings of commitment and responsibility toward a neighborhood (e.g., Brown, Perkins, & Brown, 2003; Hipp & Perrin, 2006; Oishi et al., 2007) and may correlate with recycling behavior where community members would need to learn where they could recycle and might need to develop a habit to recycle consistently. Although we lack a precise measure for length of residence, home ownership provides a proxy (e.g., Aaronson, 2000; DiPasquale & Glaeser, 1999; Rossi & Weber, 1996). We find that home ownership associates positively with recycling (see Table 4). Coefficients, however, are nonsignificant.

6. We exclude the recycling of metal from our analysis as 10.5% of respondents stated that it does not accrue in their households (opposed to 1.9% for plastics and 1.3% for glass). Given today's packaging of consumer goods, this high rate of nonoccurrence appears implausible and may also be a socially desirable answer to avoid admitting nonparticipation in metal recycling. Indeed, stating nonoccurrence of metal waste accumulation correlates negatively with self-reported environmental concern ($r = -.088$, $p = .012$). This correlation is zero and nonsignificant for both plastics and glass.
7. Utilizing Diekmann's and Preisendörfer's (2003) index, students' average environmental concern is 3.90 (Cronbach's α is .834) and thus considerably higher than in our original survey data. Notwithstanding, students' reporting of their own recycling behavior is well in line with our findings for the general population: 45% (85%) state full participation in the recycling of plastics (glass) as compared with 48% (82%) in our original survey. A binomial test (two-sided) reveals that participation rates for plastics recycling do not differ significantly across samples ($p = .123$). However, rates differ significantly for glass recycling ($p = .032$). If we compare the student rate of glass recycling to a comparable subset of the general population sample, that is, the young and educated (age bracket 20-30, high school diploma and above), the difference is nonsignificant ($p = .553$). We further randomized the sequence of injunctive and descriptive items in the online survey and are able to reject order effects for both plastics, $F(1,639) = 0.88$, $p = .347$, $\eta^2 = .001$, and glass, $F(1,639) = 1.25$, $p = .265$, $\eta^2 = .002$.
8. Monthly average rent in Munich (12 Euro per square meter) exceeds the national average threefold. Real-estate prices approximate 6,000 Euro per square meter, which, following London (14,000 Euro) and Paris (10,000 Euro), makes Munich the third most expensive city for property purchase in the European Union (see Deloitte, 2014 for data).
9. Despite increasing effect size, confidence intervals in Figure 5d inflate for distances greater than 0.65 km due to restrictions in sample size (cf., Figure 3).
10. Taking into account decreasing marginal costs of overcoming the distance to the nearest drop-off site, one could argue that longer distances become less intrusive once respondents have already dedicated their efforts to separate household waste. We ran additional regressions using log-transformed distance as an alternative measure of recycling effort. This model specification yields almost identical results regarding Hypotheses 1 to 4 in terms of both effect sizes and significance. Goodness-of-fit tests—we relied on Long's and Freese's (2014) fitstat procedure in Stata—provide positive support for the original linear specification.

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