Public Perceptions about Waste and Recycling: "Don't Consume Less, Just Recycle More."

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Abstract
As waste generation increases around the world, associated sustainability challenges with waste management are also escalating (Kaza et al., 2018). What do Americans think are effective personal strategies they can take to reduce waste, and what perceptions do they have about the systems in place for managing waste, in particular the recycling system? In a national online survey, 863 participants reported their perceptions about waste behaviors and the recycling system. When asked about what they and other Americans could do to reduce landfill waste, most participants cited disposal behaviors (e.g., recycling) rather than source reduction behaviors (e.g., buying less). This contrasts with EPA and UN waste management recommendations to minimize impact of waste focusing on reduced waste generation as a primary strategy. However, when thinking about reducing plastic waste in the ocean, participants aligned their recommendations with experts by citing source reduction behaviors more frequently than disposal actions. Addressing our global waste problem will require a dual approach focusing on significant reduction in waste generation (i.e., the production and consumption of many material goods) while simultaneously improving circular recycling strategies. The misperceptions revealed in this research indicates the need for better public understanding about what happens to waste after it is thrown away and an increased emphasis on waste reduction strategies.

Keywords: sustainable consumption, waste, recycling, perceptions, heuristics

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Introduction

As global material consumption keeps increasing beyond sustainable levels, humans are generating more waste than ever before and yet recycling less (Ellen MacArthur Foundation, 2019; Kaza et al., 2018). Waste generation and disposal has severe upstream and downstream consequences. Producing goods that are then thrown away is resource and climate intensive, from the environmental and social degradation of sites where virgin materials are extracted to the energy used in production and transport of those goods (Ellen MacArthur Foundation, 2019; Hossain et al., 2016; US EPA, 2013a). When those goods become waste and are disposed, different waste management solutions such as simply landfilling or converting the waste-to-energy have various negative downstream effects (US EPA, 2016). Evidence of our waste crisis abounds – from predictions that plastic will outnumber fish in the oceans by 2050 (World Economic Forum & Ellen MacArthur Foundation, 2016), evidence that humans are consuming tens of thousands of microplastic particles every year with unknown health outcomes (Cox et al., 2019), and the acceleration of climate change (Ackerman, 2000). Given these widespread problems associated with waste, what do people think are effective personal actions they can take to reduce waste?

Experts recommend minimizing waste by focusing on source reduction and reuse (Hyman et al., 2015; US EPA, 2015); however, popular efforts have focused primarily on the third 'R' – recycling – rather than reduce or reuse as a sustainable waste management strategy (Jaeger, 2018). Despite the widespread acceptance that recycling has as an environmentally friendly option and its advantages when compared to other disposal strategies (e.g., landfilling, incinerating), recycling as currently practiced has several problems. Global recycling rates are low – an estimated 9% of all plastics ever produced have been recycled (Geyer et al., 2017) and the U.S. recycled only 25% of all municipal solid waste generated in 2017 (US EPA, 2017). Not all materials (most notably, plastic) can be recycled in perpetuity and often require addition of virgin materials in the recycling process (Sedeghat, 2018). In the U.S., recycling programs vary considerably across the country. This lack of standardization combined with individuals' lack of knowledge and motivation leads to high rates of contamination (i.e., non-recyclable items being put in the recycling stream; Bell, 2018). Further complicating the recycling landscape in the U.S. and many other developed countries, in 2018 China passed a new policy strictly limiting the amount of recyclable materials they would import. As the U.S. used to send more recyclable materials to China than anywhere else (National Waste and Recycling Association, 2019; Semuels, 2019), this change has resulted in several municipalities increasing costs of recycling programs, shutting programs down, reducing the list of acceptable items, and incinerating and landfilling recyclables (Corkery, 2019; Lieber, 2019; Semuels, 2019).

Addressing our global waste problem will require a dual approach focusing on significant reduction in waste generation (i.e., the production and consumption of many material goods) while simultaneously improving circular strategies to recycle items for multiple additional uses of their materials. Inspired by Attari et al. (2010)'s examination of public perceptions of energy consumption and savings and Attari (2014)'s study on perceptions of water use, this research examines how people perceive waste generation and disposal. When thinking about reducing waste, do people think about disposal strategies (e.g., recycling, composting) or expert-

recommended reduction strategies (e.g., buying less, reuse)? As poor recycling behaviors inhibit high rates of resource recovery when generated waste is being disposed, what misperceptions do people have about the recycling system? In studying water (Attari, 2014) and energy (Attari et al., 2010), the authors found various misperceptions the public has about those respective systems. Similarly, we expected participants to misperceive key aspects of waste and recycling systems.

Methods

Participants 995 participants were recruited and completed a survey via Amazon Mechanical Turk (MTurk, www.mturk.com). Participants' responses were excluded if there was evidence the survey was being filled in by a bot, the participant was not proficient in English, or it was evident that the participant took the survey more than once from different accounts. After exclusions, 863 participants remained in our sample. Participants were compensated $4 dollars in their MTurk accounts. Mean age was 37.6 years (SD = 11.09) and 46.1% (391) of participants were female. Median income was between $50,000 – $79,999 and the majority of participants had a college degree or higher (554, 65.3%). Participants lived in 48 states and the District of Columbia. Politically, 48.9% (415) indicated they were liberal, 30.6% (259) indicated they were conservative, and 20.5% (174) indicated they were politically moderate.

Survey Materials This survey was modeled after Attari (2014)'s questionnaire of individual perceptions of water use. At the beginning of the survey, participants were asked four open-ended questions in randomized order. These questions were about the most effective thing they and other Americans could do to reduce landfill waste and reduce plastic pollution in the oceans. Participants then estimated how much waste they, and in a second question, the average American, generates on a weekly basis, and of those estimates what percentage of that waste is thrown away, recycled, and composted. These questions were presented in a random order.

Next, we had several measures to assess participants' knowledge of the recycling system. First, they estimated how long they thought it takes for certain items (a plastic water bottle, plastic bag, glass bottle, and aluminum can) to be made into a new product from the time they are collected when recycled. We then asked participants to estimate the percent of plastic that has been recycled or has ended up in landfills/the natural environment out of all the plastic that has ever been produced. Participants indicated how much they (and the average American) know about recycling on a Likert scale from 1 ("None at all") to 5 ("A great deal). To assess actual recycling knowledge, participants then indicated whether they thought a series of 18 items (e.g., paper coffee cup, waxed beverage carton, aluminum can, used diaper) were "recyclable at almost all recycling facilities", "recyclable, but only at select recycling facilities", or "not recyclable anywhere." These categories were chosen because what is recyclable varies considerably from one location to another. For example, aluminum cans are recyclable almost everywhere, items like waxed beverage cartons and coffee cups are accepted in some locations and not in others, and used diapers or paper towels are not recyclable anywhere in the U.S. Recyclability of each item was assessed using the website Earth911 (earth911.com)'s recycling guide, a website that the EPA links to on their "How Do I Recycle?" page for users to find recycling resources and locations (US EPA, 2013b).

We also asked participants to indicate the extent to which they engaged in behaviors that can contaminate recycling. These included 'wishcycling' behaviors (i.e., placing non-recyclable items into recycling containers without knowing whether or not they are recyclable; Robinson, 2018). Participants indicated how often they (and the average American) put something in the recycling that they are not sure is recyclable on a Likert scale from 1 ("Never") to 5 ("Very often"). To assess beliefs about contamination behaviors, we asked participants to indicate the extent to which they agreed with statements on a Likert scale from 1 ("Strongly disagree") to 5 ("Strongly agree"). For example, "If someone does not know whether or not something is recyclable, it is better for them to throw it away than to put it in a recycling bin" or "When recycling, it is not a big deal if items have some food residue left on them."

Participants then filled out a series of questions to assess whether or not they considered waste when making purchasing decisions. Sample questions include: "How often do you take into account how you will dispose of an item when you purchase it?" and "How often do you decide NOT to purchase something because you are concerned about creating waste?" which participants answered on a scale from 1 ("Never") to 5 ("Very often"). We also asked participants whether or not they buy products specifically because they are made out of recycled materials, and, if so, what kinds of products they buy for this reason. Lastly, participants responded to standard demographic questions.

This research was approved by the University of Virginia's Internal Review board and pre-registered through the Open Science Foundation (osf.io).

Conclusions

Perception of the "Most Effective Thing." Participants responded to a series of open-ended questions about the most effective thing they and other Americans could personally do to reduce landfill waste and reduce plastic pollution in the oceans. Two judges identified 37 categories by reviewing the first 100 surveys together and then independently coding the remaining surveys, which were later collapsed into 30 categories. Interrater agreement was very high for all four questions, κ's > 0.8. Similar to Attari (2014)'s categorization of actions for water as curtailment or efficiency, we then classified each action as either a disposal or source reduction behavior. Some items (e.g., "the three Rs") were identified as both source reduction and disposal, whereas others defied this process of categorization and were put under miscellaneous (i.e., indirect or other pro-environmental behaviors, such as "drive more fuel-efficient vehicles").

When thinking about reducing landfill waste, the majority of participants recommended disposal actions such as recycling (Table 1). This was an expected finding, as recycling is widely seen as a pro-environmental behavior (Dunlap et al., 2000) and infrastructure and messaging encouraging recycling is prevalent in the U.S. This contrasts with expert recommendations for waste management strategies (see Figure 1). Many participants also indicated the importance of mindful or sustainable purchasing habits to reduce landfill waste, including purchasing items with less packaging, products that could be easily recycled, or durable items that would not break down easily. This suggests that people are connecting waste generation to their

purchasing behaviors, but instead of foregoing buying items they are trying to buy products that produce less waste.

Activity	**Source reduction (SR) or Disposal (D)**	**You**	**Other Americans**
Recycle	D	43.2%	43.7%
Reuse	SR	8.7%	8.8%
Vague/miscellaneous suggestions (e.g., "Waste less")	--	7.6%	8.1%
Use less plastic	SR	7.2%	6.3%
Consume or buy less	SR	7.0%	7.8%
Compost	D	4.5%	2.4%
Purchase items with less packaging	SR	3.7%	3.7%
Mindful purchasing	SR	2.8%	2.3%
Purchase items that can be recycled	D	2.0%	2.0%
Buy biodegradable products	D	1.4%	1.2%
Donate or sell old items	D	1.4%	1.4%
Indirect/other pro-environmental behaviors	--	1.2%	2.0%
Advocate for systemic change	--	1.2%	1.3%
Burn/bury waste	D	1.0%	.5%

Table 1: Perceptions of single most effective thing to reduce landfill waste.

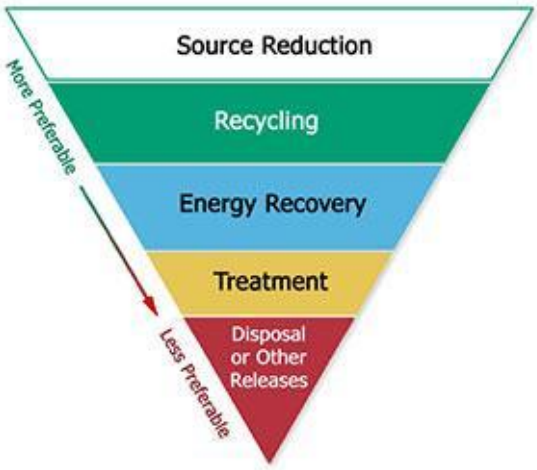

Figure 1: EPA Waste Management Hierarchy (U.S. EPA, 2019).

However, when thinking about reducing plastic in the oceans, the majority of participants cited source reduction behaviors such as using less plastic (Table 2). This was an unexpected finding that aligns with expert recommendations to reduce waste. In contrast to landfills, making the ocean salient led individuals to think higher on the waste management hierarchy. This could be because people have a sense that waste "belongs" in landfills and not in the ocean. Emphasizing that waste does not belong in the natural areas where landfills are found may be a strategy to get people to think about reduced consumption rather than waste disposal strategies. Another reason that thinking about the ocean leads people to land on the expert recommendation may be the amount of publicity ocean plastic has received in recent years and its negative

effect on marine animals and human health. Similarly, highlighting the various environmental problems with landfills (e.g., methane gas production, groundwater contamination, public health issues), which are the most common destination for waste in the U.S. (U.S. EPA, 2017) may make issues with waste generally more salient for the public.

Many participants also mentioned the importance of not littering (with several specifically emphasizing not to litter or bring plastic near the ocean), suggesting that people tend to think of ocean plastic comes from proximal dumping and do not have accurate understandings of the many ways that plastic waste can end up in the ocean (e.g., fishing equipment, in transit to landfills or recycling centers, from rivers, etc.). Therefore, there is a need for greater transparency and awareness about the various ways that waste arrives to the ocean beyond beach proximity. Participants also recommended participating in beach-cleanups, suggesting that many people are thinking about remediation strategies after waste has already been produced rather than reducing sources of waste in the first place.

Activity	**Source Reduction (SR) or Disposal (D)**	**You**	**Other Americans**
Use less plastic	SR	37.9%	36.1%
Recycle	D	22.4%	24.5%
Reuse	SR	10.1%	8.7%
Don't litter	D	4.9%	7.5%
Vague/miscellaneous suggestions (e.g., "Waste less")	--	4.2%	5.2%
Purchase items with less packaging	SR	3.7%	2.0%
Participate in beach clean-ups	--	2.9%	2.1%
Advocate for systemic change	--	2.8%	3.5%
Consume or buy less	SR	2.4%	1.7%
Substitute other materials	SR	2.2%	2.2%
Buy biodegradable products	D	1.4%	.7%
Spread awareness/educate others	--	1.2%	.6%

Table 2: Perceptions of single most effective thing to reduce plastic pollution in the ocean.

Perceptions of Waste Generation and Disposal

Before conducting this survey, a pre-test was done to test survey language for participant understanding. The EPA provides per capita waste generation estimates on a daily basis, but pre-test participants found it easier to think about how much waste they generated and disposed of on a weekly basis. Therefore, in the current study we asked participants to estimate how much waste they generated on a weekly basis, and how much of that waste they threw away, recycled, and composted. We also asked participants to estimate the same parameters for the average American.

Participants estimated that they generated significantly less waste (M=22.7 lbs. per week, SD=32.6) than the average American (M=28.7 lbs. per week, SD=25.8), $t(859) = -6.9$, $p = .000$). Although they also estimated that they generated significantly less

waste than EPA estimates of per capita waste generation $t(860) = -8.0$, $p = .000$), participants tended to have a better than expected understanding of how much waste they and average Americans generate (see Figure 2). This may be because waste is a more tangible than energy and tends to accumulate in one place, unlike water which tends to be measured and experienced as a flow. In most of their estimations, participants demonstrated the better-than-average effect (Alicke & Govorun, 2005) – that is, they estimated that they generated less waste, threw away less, and recycled more than what they estimated for the average American and what the EPA estimates (US EPA, 2017). In composting, however, participants estimated that they compost less than the average American and less than what the EPA estimates. This may be because people tend to think of food waste for composting and not grass and yard trimmings, which make up a large majority of the composting data from the EPA. Additionally, it may be because there are far fewer municipal composting programs than trash and recycling (Sheppard, 2012). Conversely, this difference could also be an example of the better-than-average effect, as generating food waste that has to then be composted may be perceived as a negative action. Correcting perceptions of how much waste individuals generate and making it more salient may be an important component of addressing waste at the point of generation.

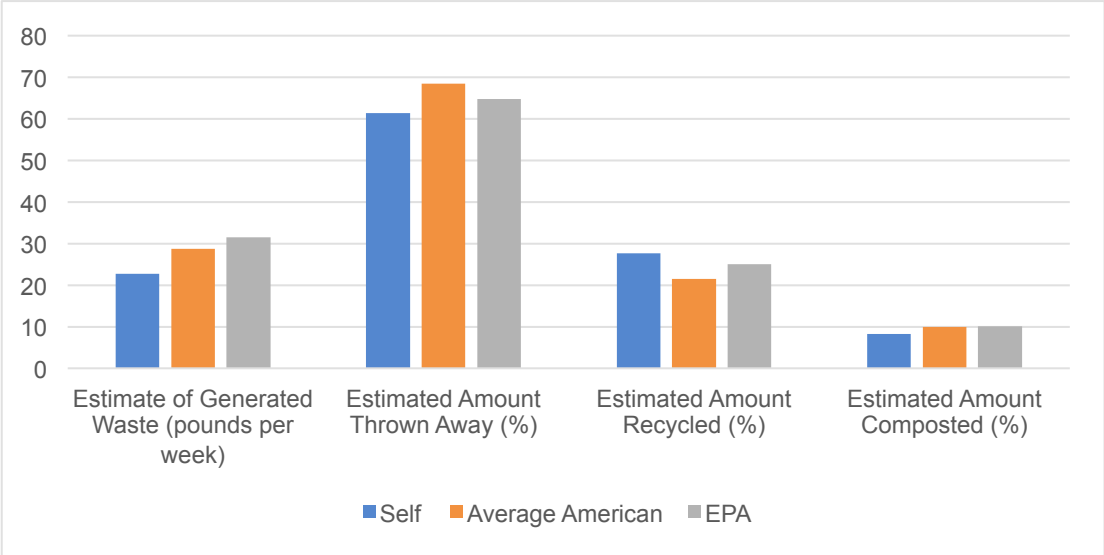

Figure 2: Participant Estimates of Waste Generation and Disposal.

Perceptions of the Recycling System.

Do people have any idea what happens to their waste after it is thrown "away" or put in a recycling bin? One way that we assessed perceptions of the recycling system was by asking people to estimate how long it took a water bottle, plastic bag, glass bottle, and aluminum can to be made into a new product from the time they were collected. We also asked a series of experts in the recycling industry to estimate the same, and we compared expert estimates to participant estimates. We excluded any response that had an estimate of over 25 years, as these were considered to be extreme outliers. In every case, participants thought items took much longer to be recycled than experts estimated. We excluded all estimates over 25 years. For water bottles, participants thought it took them about five and a half months to be made into a new product compared to a mean expert estimate of less than 2 months, (M=165.3 days, SD=533.7), $t(843) = 6.3$, $p = .000$). Similar overestimates were true for plastic bags

(*M*=170.8 days, SD=543.5), $t(841) = 7.5$, $p = .000$), glass bottles (*M*=166.6 days, SD=577.9), $t(842) = 7.0$, $p = .000$), and aluminum cans (*M*=144.4 days, SD=427.6), $t(844) = 4.7$, $p = .000$).

These misperceptions about how long items take to be recycled may be a result of increased news coverage about recycling and China, or a general sense of a broken or inefficient recycling system. Knowing what products become when they are recycled into new items (e.g., seeing a plastic bottle become a jacket when recycled) encourages good recycling behaviors Winterich et al., 2019), and the same could be true for general familiarity with the recycling process. If individuals think that the recycling system is inefficient or disjointed, that might affect their recycling behaviors negatively. An alternative explanation might be that people think the recycling system is more complex than it is, which might account for wishcycling and contamination behaviors. For example, if people think that recycling processors take a long amount of time to clean and sort recyclables before sending them downstream, that might lead them to put dirtier or unrecyclable items in the recycling stream because they think it has the capacity to deal with them.

We also asked participants to estimate the amount of plastic that has been recycled and that has ended up in landfills/the natural environment out of all plastics ever produced. Participants greatly overestimated the percent of plastic they thought had been recycled when compared to expert estimates (Geyer et al., 2017), but still estimated a surprisingly low number (*M*=23.1%, SD=20.2), $t(844) = 23.1$, $p = .000$). This suggests that participants are familiar with problems associated with recycling – yet they still perceive it as their most effective option to reduce landfill waste.

When assessing their own recycling knowledge, participants thought they knew a moderate amount (*M*=3.0, SD=0.9) on a 5-point scale and estimated that they knew more than the average American (*M*=2.6, SD=0.8), $t(844) = 14.0$, $p = .000$). On the measure of actual recycling knowledge, most items had only one acceptable answer (e.g., "not recyclable anywhere). However, due to regional variations in recycling discussed above, for some items we accepted multiple answers as correct. For example, for glass we accepted either "Recyclable at almost all recyclable facilities" or "recyclable, but only at select recycling facilities" because until recently glass was recyclable almost everywhere, but many municipalities have stopped accepting it in curbside collection (Winterich et al., 2019). For each answer, participants either got 1 (correct) or 0 (incorrect) points, and this number was summed and averaged over the total number of items for a total score out of 100%.

Overall, participants performed better than expected on the assessment of recycling knowledge with a mean score of 66.7% (SD=15.45). However, that score belies some grave misunderstandings of the recycling system. For example, 22.4% of participants indicated that they thought used diapers were recyclable at all recycling facilities (8.3%) or select facilities (14.1%). Dirty diapers have been found in waste marked as recyclables (Choi, 2019). While there is technology that can recycle dirty diapers (Khoo et al., 2019), none is currently in use in the U.S. (Jewkes & Geller, 2018; Recycling Today, 2003). Some specialty diapers can be composted through special services, but this is a different process than recycling. Items like used diapers put in the recycling stream in the U.S. contaminate recycling loads, which adds cost and can lead to otherwise-recyclable items being trashed (Robinson, 2018).

In their assessment of wishcycling behaviors, participants indicated that they put items in the recycling that they are not sure is recyclable rarely or occasionally (M=2.4, SD=1.0) but that they thought the average American did it more frequently (M=3.5, SD=0.8). Participants were uncertain about other contamination behaviors, however, indicating that they weren't sure whether or not it was better to throw away or recycle items when uncertain and how important it was for recyclables to be clean and free of food residue. For consumers, improving messaging about what can and cannot be recycled and in what condition is important, and so too is reducing the number of items produced that cannot easily be recycled in existing systems. For recyclers, understanding how consumers perceive the recycling system could enable technology-aided adaptations to accommodate consumer behavior.

Purchasing Behaviors and Waste Awareness

Participants report that they tend not to think about waste generation at the point of purchase. When asked: "How often do you take into account how you will dispose of an item when you purchase it?" on a scale from 1 ("Never") to 5 ("Very often"), participants reported that they rarely to occasionally think about it (M=2.8, SD=1.2). Similarly, participants indicated that they would likely still buy items that came in packaging that could not be recycled or composted (1 representing definitely would not buy and 5 indicating definitely would buy, M=3.6, SD=.93). They also indicated that they rarely forego a purchase due to concerns about creating waste (1 representing they never forego a purchase due to waste concerns, 5 indicating they do so very frequently, M=2.5, SD=1.1). Being more concerned about waste at the point of purchase was significantly associated with throwing away less waste, $r(850) = -.529$, p=.000, and recycling $r(850) = .356$, p=.000 and composting more $r(850) = .403$, p=.000. However, it was not associated with reduced waste generation. This indicates that even when people think about waste at the point of purchase, they tend to think about 'sustainable' waste disposal strategies and not about avoiding waste generation in the first place. Rather than focus messaging on recycling and composting, future waste strategies should also incorporate messaging focused on purchasing behaviors that avoid waste creation.

Discussion

When asked about effective actions they can take to reduce waste, participants answered differently depending on the spatial description of where waste ended up. When thinking about landfills, participants recommended disposal strategies, but when thinking about the ocean, participants thought higher up on the waste management hierarchy and recommended reduced consumption strategies. This may be because people think that waste "belongs" in one of those locations and not in the other. Future research is needed on why oceans, and not landfills, gets people to think higher on the waste management hierarchy. Understanding those mental models will be an important component to designing a better waste management system and changing communication strategies regarding the naturalness of waste.

This research has several limitations, including using an Internet sample of participants that is not representative of the U.S. population and lack of monetary rewards for accuracy. Additionally, estimates of recycling time come from experts

and not actual recycling data. The behaviors and attitudes reported here were self-reports, which may not be totally reflective of actual participant actions and beliefs.

This research shows several misperceptions that people have about waste systems that span both waste generation and disposal. Education about recycling has been widespread, yet issues stemming from poor consumer behavior persist. This research suggests need for a better designed national recycling system, products that are simple to recycle, and better education on source reduction as an effective waste management strategy.

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Author Contributions

M.B. and S.Z. designed research; M.B. performed research; M.B. and P.H. analyzed data; M.B., wrote the paper; P.H., S.Z., and L.K. offered feedback and edited the paper.

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