Plastic Recycling and Public Perception

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Abstract While the triangular "chasing arrows" logo is widely believed to mean "recyclable," it is actually part of the public domain and a product does not have to be recyclable in order to bear the logo. Many plastic packages display the logo while the recyclability of plastic is a complex and debatable issue. This study examines how residents of Berkeley and Oakland, California perceive the recyclability of plastics, hypothesizing that most people rely primarily on the logo to ascertain recyclability, most others think all plastics are recyclable, and more Oakland than Berkeley residents think all plastics are recyclable. Participants were given a survey regarding their recycling knowledge and habits and were asked to determine the recyclability of four plastic containers with different characteristics. Two trends dominated the results: 1) A very high proportion of people answered in accordance with the presence or absence of the logo, confirming the logo as a primary source of information on recyclability. 2) A very high proportion of people answered that all plastics are recyclable. This was indeed exhibited more in the Oakland residents, though not by a conclusive amount. Only 0.3 % of the participants were able to identify all four containers correctly, highlighting the need for education. Residents play a key role in the waste system and are faced with many choices regarding purchasing and disposal. These decisions must be based upon a clear understanding of local and global production and disposal processes rather than a murky understanding based upon an unclear marketing tool.

Introduction

The "chasing arrows" logo, shaped like a triangular Mobius loop, has become a universal symbol for recycling. It was created in 1970 by University of Southern California student Gary Anderson for a design contest held by the Container Corporation of America (CCA), a large producer of recycled paperboard. At the time, there was a burgeoning awareness of environmental issues and the Chicago-based company offered free tuition to a college of choice for whatever student could best graphically represent the recycling process. CCA promoted the use of the logo before attempting to trademark it and then met trouble in the application process due to its popularity. The logo fell into the public domain and its usage increased at an even faster rate (Jones and Powell 1999). The Society of the Plastics Industry (SPI) instituted a voluntary labeling system in 1988 that consists of a code number placed inside the symbol to specify the primary resin used in the product (SPI 1988). Seeing the value in differentiating the types of plastics, 39 states have required the use of the SPI codes on rigid plastic containers distributed in the state, solidifying the logo's presence even further (Wigotsky 1995). Other countries followed suit and started using the logo or developing their own iterations, and now many people across the globe associate the logo with recycling while the products on which they appear actually do not have to be recyclable.

There are a number of issues that contribute to the complexity of plastic recycling. The most basic of these is the definition of recycling. For example, in its Guides for the Use of Environmental Marketing Claims, the Federal Trade Commission (FTC) asserts that recycling includes the reuse, reconditioning, and remanufacturing of products or parts in another product. This rather broad definition includes both primary and secondary recycling. Primary recycling refers to a process in which a used product is converted into a product similar to the original product. Secondary recycling refers to a process in which a used product is converted into a product with less demanding physical and chemical characteristics than the original product. Primary recycling is generally more desirable because it reduces the need for virgin material and eliminates the need to create new market niches for secondary products (Hegberg *et al.* 1992). Plastics are most easily applied in the secondary recycling market, yielding products like plastic lumber, farm animal pens, boat docks and traffic barriers (Mustafa 1993). Some people may not include secondary recycling in their conception of recycling, so it is important to be clear and specific about definitions to avoid confusion.

Plastic recycling is subject to other complications. There are more than 50,000 types of plastic polymers used in consumer products (Williamson 2005, pers. comm.). The most common plastics can be grouped into two main categories and have varying characteristics with regard to recyclability. Thermoplastics, the most widely used type of plastics, include polyethylene (PE), polyethylene terephthalate (PET or PETE), low-density polyethylene (LDPE), high-density polyethylene (HDPE), polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), polycarbonates (PC), and polyamide (PA). The heating and cooling processes are reversible because they do not change the chemical characteristics, making thermoplastics generally suitable for recycling. The molecular chain does progressively degrade, however, so the potential for recycling is finite. Thermosetting plastics such as polyurethane (PUR), polyesters, and epoxy resins are not as suitable for recycling as thermoplastics because their chemical features change when heated (Smits 1996).

The types of plastic acceptable for recycling depend on location. The FTC recommends that if recycling facilities are not available to a substantial majority of consumers or communities for a particular container, recyclability claims "should be qualified to disclose the limited availability of recycling programs for the container." However a logo embedded on the bottom of a container is considered inconspicuous and does not constitute a recyclability claim according to the FTC. Regardless, these guidelines are not legislative rules and are not enforceable by law (FTC, elect. comm.).

The viability of markets for recycled plastic depends on location and the type of plastic. The markets for recycled plastic are generally small because they are relatively new and they are at a disadvantage because governments provide hidden subsidies to the producers of virgin materials in the form of tax breaks or free services. These subsidies affect the supply curve of virgin output, increasing the amount of virgin output and lowering the price of virgin materials. This lower price "lowers the price paid for the closely substitutable recyclable materials and discourages their collection and recycling" (Porter 2002).

There are markets for mixed plastic waste, however a resin stream must be homogeneous if it is to be recycled into products in competition with products produced from virgin resins (EPA *et al.* 1991). Separation by resin type is typically necessary to ensure a feedstock of suitable quality and also to avoid problems related to contamination. For example, if PVC is melted with PET, hydrochloric acid can form and corrode the metal parts of the extrusion machines (ECE 1992).

Since the postconsumer plastic collected from households is usually heterogeneous and contaminated, sorting poses a costly problem to collection agencies. Also, plastics are often mixed with additives like pigments, fillers, plasticizers, fire decelerators, antioxidants, and anti-statica. These additives improve technical performance or marketability but complicate prospects for recovery (Smits 1996).

Despite these complications, the industry has put a great amount of energy into creating a positive image for plastic. Much of this has been in the form of websites and television advertisements that brag, "plastics make it possible" and ask consumers to "take another look at plastics" (Environmental Defense Fund 1994). The American Plastics Council (APC) and industry allies lobbied to defeat efforts made in 3 states to modify the use of the chasing arrows logo (Ecology Center 1996). More recently, APC has undertaken a campaign to support and promote the collection of "All Plastic Bottles." They developed a website and media tools to encourage recycling coordinators to adopt programs that accept all plastic bottles, reasoning that "since 95 percent of all plastic bottles produced are PET and HDPE, it is reasonable to assume that the more bottles you collect overall, the larger the percentage collected will be PET and HDPE" (APC, elect. comm.). While this may indeed cause the public to recycle more plastic bottles, it does little to help the public understand plastic bottle recycling.

Previous research has revealed a crucial link between behavior-specific knowledge and environmental behavior. Sia *et al.* (1985) studied environmental behavior in Illinois. They found that knowledge of specific environmental behaviors was a significant predictor of their behavioral index, though to a lesser extent than perceived skill and environmental sensitivity. In another Illinois study, Vining and Ebreo (1990) observed some important traits relevant to the relationship between knowledge and recycling behavior. Of the recyclers and nonrecyclers they studied, they found that recyclers were better informed, knew more about local recycling programs, and gave more accurate information about the recyclability of certain materials. A study conducted in 1994 by the Saint Paul Neighborhood Energy Consortium (NEC) found that 70 % of the 804 people surveyed believed the chasing arrows logo means "recyclable" and many believed it means the product is made from recycled material (Saint Paul Neighborhood Energy Consortium 1994). In a study on household waste in Exeter, UK, Barr (2002) found that knowledge of recyclables was better for "classic" recyclables like glass, aluminum cans, and newspaper than for "marginal" recyclables like plastic bottles. Interestingly, he also found that

75 % of residents with curbside recycling thought other plastics beside plastic bottles could be placed in the bin when actually only plastic bottles are permitted.

As the importance of knowledge about recycling to recycling behavior has been demonstrated, this study further investigates public knowledge of plastic recycling, with special attention given to the chasing arrows logo. Oakland and Berkeley, California, provide an interesting testing ground for this research. Oakland has adopted the "All Plastic Bottles" approach recommended by APC and residents are told to recycle all narrow-necked plastic bottles, regardless of SPI code number. It recently distributed new bins for curbside recycling and made efforts to inform residents of the recycling guidelines. These efforts include instructions that came with the bins, guidelines on the Internet, and advertisements on city buses. Instead of the "All Plastic Bottles" approach, Berkeley specifies that to fit the collection guidelines, plastics must be narrow-necked bottles or jugs and must be either #1 (PET) or #2 (HDPE) plastics. The Ecology Center, the organization contracted by the City of Berkeley to conduct curbside recycling, has made efforts to inform residents of the recycling guidelines. These efforts include instructions that came with the bins and guidelines on the Internet. The Ecology Center has also done work to educate the general public about plastic recycling via free literature at their store and the "Recycled Content" newsletter, available online. This study explores the hypothesis that most people identify the recyclability of plastic bottles in accordance with the presence or absence of the chasing arrows logo rather than on whether they are recyclable or not recyclable. The study also explores the additional hypothesis that of those whose decisions about the recyclability of plastic bottles do not always coincide with the logo, most people think all plastics are recyclable, and that this trend will be more pronounced in Oakland than in Berkeley due to Oakland's "All Plastic Bottles" approach. The results of this study could yield useful information about recycling behavior. By showing that actions taken by the plastic industry are causing erroneous recycling behavior, this study could place some of the accountability for the confusion about plastic recycling on the plastic industry. The study could also help identify good ways to provide people with the information necessary to overcome the confusion.

A noteworthy point is that these communities appear to be particularly conscious of environmental issues, including waste. For example, Berkeley and Oakland are both located in Alameda County, which diverted 55 % of its solid waste from landfill disposal in 2000. In 1990,

voters in Alameda County approved a citizen's initiative, the Waste Reduction and Recycling Initiative, establishing a goal of 75 % waste diversion by 2010 (ILSR 2002, elect. comm.). Berkeley was one of the first cities in the United States to initiate curbside recycling and one of the first cities to ban polystyrene (Ecology Center, elect. comm.). In June 2000, Berkeley City Council passed a resolution, "Adopting a Comprehensive and Unified Plastics Policy," recognizing plastics as a "growing and problematic part of the waste stream" (Grassroots Recycling Network, elect. comm.). Significant misperceptions about recycling in a place with a relatively high degree of interest in it are a good indication that misperceptions are even more widespread in other cities with a lower degree of interest in recycling.

Methods

To represent as wide a segment of the population as possible and keep selection bias to a minimum, I conducted surveys in front of grocery stores during morning, afternoon and evening hours of both weekdays and weekends. I chose grocery stores because many plastic products are sold there and most people visit grocery stores at least occasionally. The stores included 3 Safeways, 2 Andronico's, Albertson's, Berkeley Bowl, and Piedmont Grocery. The stores covered a good range of Berkeley and Oakland. By surveying in front of different types of stores in different neighborhoods, I sought to reach people in various economic conditions. By surveying during different days of the week and times of the day, I sought to reach people who work during different days and times. I only surveyed people on their way out of the store and I invited everyone within earshot and eye contact to take the survey.

The survey itself was completely anonymous (see Appendix A). I asked the subjects questions and wrote down their responses. At the onset, I asked, "Do you live in Berkeley or Oakland? Which one?" If they did not live in either city, I told them, "Thanks anyway." If they were eligible, I recorded their age and gender. Asking the subjects outright about their knowledge of the meaning of the logo could, in itself, spark doubt and skew the results. Therefore, the survey began with something of a recyclability quiz. Since there are different ways to interpret the term "recyclability," I provided a clear definition of recyclable as "something that can be turned into the same type of product if you put it in your curbside recycle bin at home," referring to primary recycling. Then I handed the respondents four containers one by one and asked them to say if the container is recyclable or not recyclable. The first container

was a #7 (OTHER) ketchup container. It was neither recyclable in Berkeley nor Oakland. It did not display the chasing arrows logo. The second container was a #5 (PP) salsa tub. It was also not recyclable in either city, but it displayed the chasing arrows logo. The third container was a #2 (HDPE) sunscreen bottle. It was recyclable in both cities, but did not display the logo. The fourth container was a #1 (PET) water bottle. It was recyclable in both cities and displayed the logo. If the participant asked any questions or tried to get a hint, they were denied any further information and asked to simply choose an answer to the best of their ability.

To get at the role of environmental values in purchasing decisions, I asked the respondent to rate, on a scale of 1 (Never) to 10 (Always), how often they consider the environmental implications of a product's packaging when making a purchasing decision. Then I asked if the respondent knew that the chasing arrows logo does not guarantee recyclability. If they knew this, I asked where they learned about it in order to get an idea of effective education outreach methods. I informed the respondents about the logo and answered any of their short questions. I concluded by giving them the top portion of the survey, which contained information on how to contact me with further questions and how to find more information about recycling in the San Francisco Bay Area. Although I did spend time answering questions and talking to people, it was helpful to give them information to take home so I could proceed with more surveys.

Results

A total of 308 surveys were administered. Looking at the responses for each container individually, 49 % thought the ketchup container (not recyclable, no logo) was recyclable and 51 % thought it was not recyclable. 72 % thought the salsa tub (not recyclable, logo) was recyclable and 28 % thought it was not recyclable. 35 % thought the sunscreen bottle (recyclable, no logo) was recyclable and 65 % thought it was not recyclable. 94 % thought the water bottle (recyclable, logo) was recyclable and 6 % thought it was not recyclable.

More important than the responses for the individual containers, however, are the trends for all four containers. I used chi-square analysis to interpret the data. With four containers and two possible responses for each container, there are a total of 16 possible outcomes. This is like drawing with replacement from a box whose contents are the 16 possible outcomes. Let's assume the respondents don't know if each container is recyclable or not. This is a reasonable assumption given the complexity of plastic recycling. If respondents have no source of

information to tell them about the recyclability of the products, they have a 50 % chance of getting each one right and the 16 possible outcomes each have an equal probability of getting chosen. The expected frequency of each response is based on this probability and is (1/16) x 308 = 19.25. The null hypothesis says the difference between the observed frequency and the expected frequency is due to chance. A large chi-square value points to definite influences on peoples' perceptions of recyclability and the outcomes with the largest deviations from the expected value point to the biggest influences on these perceptions.

Table 1 shows the results of each possible outcome. "N" refers to a response of "Not Recyclable" and "Y" refers to a response of "Recyclable" in the order presented in the survey.

Table 1

Response	Expected Frequency	Observed Frequency
1. NNNN	19.25	12
2. NNNY	19.25	**44**
3. NNYN	19.25	1
4. NYNN	19.25	4
5. YNNN	19.25	0
6. NNYY	19.25	1
7. NYYN	19.25	1
8. YYNN	19.25	2
9. NYNY	19.25	**87**
10. YNYN	19.25	1
11. YNNY	19.25	12
12. NYYY	19.25	8
13. YNYY	19.25	15
14. YYNY	19.25	**41**
15. YYYN	19.25	0
16. YYYY	19.25	**79**

The chi-square statistic for these data is 332. The p-value is < 0.0001, meaning there is less than a 0.01 % chance of obtaining values equal to or more extreme than the ones obtained if the differences between the observed and expected frequencies are due to chance.

Row 9 of Table 1 refers to respondents who chose an answer corresponding to the presence or absence of the logo on all of the containers. 28.2 % of all respondents answered this way. This was the largest contributor to the chi-square statistic.

Row 16 of Table 1 refers to respondents who thought all plastics were recyclable. 25.6 % of all respondents answered this way. This was also a large contributor to the chi-square statistic. (41/144) = 28.4 % of Oakland residents held this belief. (38/164) = 23.1 % of Berkeley residents held this belief. To determine if this difference was statistically significant, I performed another chi-square test, using the proportion of total responses for this category to determine the expected value for each city. The chi-square statistic for these data is 0.86 and the p-value is 0.35.

The average for the "scale of 1 to 10" question was 6.2.

67 % of all respondents thought the logo guarantees recyclability.

0.3 % of all respondents were able to identify all four containers correctly.

Discussion

The results of the chi-square test on the 16 possible outcomes of the recycling quiz give an extremely high chi-square statistic and an extremely low p-value. This is extraordinarily strong evidence that the differences are not due to chance and that something is causing the population to respond in a certain way. The bold numbers in Table 1 give some insight. The highest observed frequency is 87 and corresponds to the responses NYNY. These correspond to the containers with no logo, logo, no logo, logo. This is very strong evidence that people rely heavily on the chasing arrows logo to give them information on recyclability, confirming the first part of my hypothesis. It follows that if people are using this logo as knowledge to guide their behavior, the logo should be accurate. The FTC should update its Guides for the Use of Environmental Marketing Claims to reflect that the chasing arrows symbol, even if located on the bottom of a container, constitutes a recyclability claim. Policy measures to disallow the use of the logo unless recyclability in most areas can be proven or to require a qualifying statement

about the location-dependence of recyclability would help give consumers a clearer sense of what the symbol really means.

The next highest observed frequency is 79 and corresponds to the responses YYYY. This is very strong evidence that people think all plastics are recyclable, confirming another part of my hypothesis. While this was exhibited to a greater extent in Oakland residents than in Berkeley residents, the difference was not statistically significant and thus does not confirm that part of my hypothesis. However, I feel the difference would become more significant with a higher sample size. Regardless of the difference between the two cities, this response reveals that the perception of all plastics as recyclable is widespread. These results are similar to the findings of the aforementioned Exeter study. This misperception could be due to a number of things, some stemming from actions taken by plastic manufacturers and the plastic industry as a whole. I think the most important reasons for the misperception are the widespread use of the logo on plastic containers, advertising to make plastics seem environmentally friendly, and the push for collection agencies to collect all plastic bottles.

Two other outcomes showed relatively large deviations from the expected value. The response NNNY had an observed frequency of 44. This may be due to the fact that many people think most plastics are not recyclable, but still identified the water bottle as recyclable because it is such a popular plastic. The water bottle is indeed probably one of the most recognizable representatives of a recyclable plastic, with 94 % of respondents identifying it as recyclable. Many respondents said it was recyclable the moment they caught a glimpse of it and didn't even feel the need to inspect the container. The response YYNY had an observed frequency of 41. The not recyclable response was in reference to the sunscreen bottle, which was the container respondents seemed to have the most trouble with. The respondents in this category may have been inclined to think all plastics are recyclable, but were skeptical about the sunscreen bottle because it was particularly confusing. While I think the containers in this study were well chosen for their categories, it would be interesting to perform the survey again with different containers. I think the major trends would be the same, with some minor variations due to the unique characteristics of each representative container.

The 67 % of respondents thinking the chasing arrows logo guarantees recyclability matches closely to the 70 % found to hold the same belief in the St. Paul study. Of those who did know the logo does not guarantee recyclability, the most common way they learned about it was

through recycling collection guidelines. Others learned about it through school, word of mouth, articles, and the Ecology Center. A striking result is that only one respondent was able to identify the recyclability of all four containers correctly. This reveals that people need to learn more about how to properly dispose of specific containers, however many of the possible outcomes showed low observed frequencies like this. A larger sample size would yield more revealing and reliable results, as these may have been slightly truncated on the low end.

This research touches upon some serious problems facing society with regard to our waste. The confusion surrounding plastic recycling has been detrimental to society but beneficial to the plastic industry. It has made plastics more attractive as environmentally friendly yet has simultaneously made source reduction less likely, sorting more difficult, and education efforts more necessary. The plastic industry needs to take accountability for causing at least some of this confusion. By being clear and honest about the recyclability of its products and by creating markets for recycled plastic, plastic manufacturers and organizations like APC and SPI have a great deal of power to effect some positive change.

There are many other things that can be done to help the situation. Balancing the playing field for virgin and recycled outputs would do a great deal of good for the recycling industry and for society as a whole. This could be accomplished if the government removed subsidies for virgin outputs and taxed their external costs. While previous attempts to regulate the use of the chasing arrows logo have failed, it might be possible to replace it with a new symbol to be used as an international standard. This would help stem confusion and would foster communication and cooperation in the international community in the process. Also of increasing concern is the reliance of materials on extractive industries like natural gas, crude oil, and coal. In the long term, we will need to see a shift to non-extractive industries. And of course, a prerequisite for all of this is a working knowledge of the waste stream. People need to understand the waste hierarchy and the advantages of source reduction and reuse. Education via school, the Internet, news articles, advertisements, leaflets, collection guidelines, word of mouth, or any other means, must be used to change knowledge and attitudes before we can expect any changes in behavior. It was encouraging to find that many people were genuinely interested in the research and wanted to learn more about recycling. Technical, economic, and policy measures can all be used to move our current situation in a positive direction, but enough emphasis cannot be given to the

importance of a higher level of understanding and awareness among the public of the complexities of the modern waste stream.

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Appendix A

This short, anonymous, voluntary survey is for a senior thesis in Environmental Science at UC Berkeley. There are no risks or benefits to study participants.

For questions regarding this survey, contact David Siddiqui at: **siddiqui@berkeley.edu**

For more information about recycling and waste management in the Bay Area, visit:
http://www.stopwaste.org --- http://www.ecologycenter.org --- http://www.ncrarecycles.org

---------- Detach above section and give to participant ----------

Date and Time:

Survey location:

"Do you live in Berkeley or Oakland? Which one?" (Participant must reside in Berkeley or Oakland):

❑ Berkeley ❑ Oakland

Please mark your age group:
(Participant must be 18 or over)
❑ 18 – 27
❑ 28 – 37
❑ 38 – 47
❑ 48 – 57
❑ 58 – 67
❑ 68 and over

Gender? ❑ Male ❑ Female

"I am going to hand you four different containers one by one and I want you to tell me if you think each one is recyclable or not recyclable. This is defining recyclable as something that can be turned into the same type of product if you put it in your curbside recycle bin at home. You are allowed to inspect the container, but you are not allowed to receive any help." (Keep each container out of the participant's sight until you hand it to them.)

Container #1 (Ketchup)	Response:	❑ Recyclable	❑ Not Recyclable
Container #2 (Salsa)	Response:	❑ Recyclable	❑ Not Recyclable
Container #3 (Sunscreen)	Response:	❑ Recyclable	❑ Not Recyclable
Container #4 (Water)	Response:	❑ Recyclable	❑ Not Recyclable

"On a scale of 1 to 10, 1 being Never and 10 being Always, how often do you consider the environmental implications of product packaging when making a purchasing decision?" _____

"Did you know the 'chasing arrows' logo does not guarantee recyclability?" ❑ Yes ❑ No

If the participant answers 'yes' to the previous question, ask, "How did you learn about that?"

"Thank you for taking the time to complete this survey."