Plastic Recycling and Public Perception

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Abstract While the triangle-shaped "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 wear the logo. The vast majority of plastic packaging displays the logo while the recyclability of plastic is a complex and debatable issue. This study looks at how residents of Berkeley and Oakland perceive the recyclability of plastics, hypothesizing that most people rely primarily on the logo to ascertain recyclability and that 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 need to 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 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 many different types of plastics. 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).

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). Efforts made in 3 states to modify the use of the chasing arrows logo were defeated through the lobbying efforts of the American Plastics Council (APC) and industry allies (Ecology Center 1996). More recently, APC has undertaken a campaign to support and promote "all plastic bottle collection." They developed a website 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). 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 shown 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 will 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. Of those who do not think all plastics are recyclable, I predict that more people will identify the bottles as not recyclable based on the absence of the logo rather than actual non-recyclability.

Studying two cities allows the differences between recycling programs to be considered. Also, Berkeley is a community whose population is generally thought of as particularly environmentally conscious. For example, it 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). 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). Significant misperceptions here suggest the phenomenon may even be more widespread in other parts of the country. The confusion surrounding plastic recycling has been detrimental to society but beneficial to the plastic industry. It has made

plastics more attractive, yet has simultaneously made source reduction less likely, sorting more difficult, and education more necessary. This study could place some of the accountability for this confusion on plastic manufacturers and suggest good ways to provide people with the education necessary to overcome it.

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, Berkeley Bowl, Piedmont Grocery, and Albertson's. 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." Then 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
NNNN	19.25	12
NNNY	19.25	**44**
NNYN	19.25	1
NYNN	19.25	4
YNNN	19.25	0
NNYY	19.25	1
NYYN	19.25	1
YYNN	19.25	2
NYNY	19.25	**87**
YNYN	19.25	1
YNNY	19.25	12
NYYY	19.25	8
YNYY	19.25	15
YYNY	19.25	**41**
YYYN	19.25	0
YYYY	19.25	**79**

The chi-square statistic for this 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.

The last row in Table 1 refers to respondents who thought all plastics were recyclable (25.6 % of all respondents). (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 as a basis for expected value. The chi-square statistic for this data is 0.86 and the p-value is 0.35.

28.2 % of all respondents chose an answer corresponding to the presence or absence of the logo on all of the containers.

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 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 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 Exeter study. This misperception could be due to a number of things, many which lead to 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. In the context of all the complexities of plastic recycling, the notion that all plastics are recyclable is a gross oversimplification.

This research touches upon some serious problems facing society with regard to our waste. The plastic industry needs to take accountability for causing at least some of the confusion about plastic recycling. By being clear and honest about the recyclability of its products and by creating markets for recycled plastic, the plastic industry has a great deal of power to effect some positive change. Balancing the playing field for virgin and recycled outputs, by removing subsidies for virgin outputs and taxing their external costs, would do a great deal of good for the recycling industry and for society as a whole. And education of the public 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. 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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