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The (Mis)Understanding of the Symbol Associated with Recycling on Plastic Containers in the US: A Brief Report

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Abstract: Plastic containers are a major source of pollution and contribute to greenhouse gases. Many plastic containers are embossed with a small symbol of three arrows forming a triangle and a number in the middle of the triangle. As part of a US online study, we assessed the meaning of this symbol. Of the 808 respondents presented with a visual image of the three-arrow symbol, 81.3% reported (incorrectly) that the symbol indicated that the item could definitely be recycled and 16.3% reported that it could probably be recycled. The findings suggest that a large proportion of individuals have an inaccurate understanding of the symbol on plastics purported to indicate recycling. Plastic manufacturers should revise labels about recycling and not disseminate potentially deceptive information about the ability to recycle their products, and more effective methods such as extended producer responsibility legislation are needed to reduce plastic pollution.

Keywords: recycling; plastics; recycling images; plastic pollution; automatic processing



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1. Introduction

Plastic containers are a major source of pollution, and their deleterious impact on the health of humans, aquatic bodies, and wildlife is well-documented and substantial [1–5].

It is estimated that the annual amount of plastic entering the ocean will triple to 29 metric tons per year by 2040 [6]. Moreover, the process of petroleum extraction, which is required to produce plastic, has devastating environmental and human health consequences [7]. Proper disposal of plastics poses another set of adverse health impacts, as plastics never completely degrade. Indeed, microplastics have commonly been found in drinking water [8], while toxic chemicals in plastics can also leach into drinking water. Additionally, plastic degradation and incineration are sources of greenhouse gases [5].

To reduce plastic pollution, it is imperative to both reduce the production and consumption of plastics and increase recycling. The petrochemical and food industries have aggressively fought stricter measures to limit the use of plastics [9]. These industries have also foisted the responsibility of recycling upon consumers [10–12]. Consumer recycling can be difficult, as recycling programs across states and counties can vary widely with different technologies and sorting programs and different guidelines on what can be recycled. An EPA report identified that only 8.7 percent of produced plastic is actually recycled in the United States [6,13]. The current study focuses on consumer knowledge of recycling practices and recyclable materials, which is one critical step that must be targeted in a multipronged strategy to reduce plastic production and waste.

A review of published papers on perception and behavior related to plastic use and disposal suggested that social norms and habits are linked to plastic consumption [14]. However, one of the most strongly associated factors with plastic use is convenience. In addition, consumers tend to emphasize the role of policymakers and structural factors in plastic waste and pollution, whereas policymakers emphasize consumer responsibility.

Relatively few studies have examined factors associated with a reduction in plastic use. These include provisions of alternatives, such as water bottles [15]. Encouraging reusable bags from loss and gain frames has been found to be somewhat effective [16]. The policy instrument, however, of charging for disposable bags is widespread and effective [14]. There have also been a couple of studies on willingness to pay that have found greater willingness to pay for alternatives to plastics for both dining-in and take-out [17]. Moreover, packaging that is seen as responsible (reusable, recyclable, or compostable) has an impact on increasing purchasing intentions [18].

Regarding recycling, a 2021 review of food packaging and sustainability found that in Europe, the environmental impact of plastic was underestimated and knowledge of recyclability was low [19]. A brief online survey and qualitative study in Northern Ireland revealed a substantial gap between recycling intentions and behaviors [20]. The authors also found that plastic recycling was impeded by misunderstanding and uncertainty about which plastic materials can be recycled, reporting plastic recycling was a low priority in their daily life and perceiving that government and manufacturers have a responsibility to make plastic recycling easier.

Manufacturers routinely place a symbol on plastic containers to indicate the type of plastic from which the container is made. The symbol appears as three chasing arrows with a number in the center. The number indicates the type of resin from which it is made. The chasing arrows symbol can be misleading as it does not necessarily mean the item is recyclable, as different recycling programs accept different types of plastics. Recycling items that are not accepted by the local recycling program can cause contamination in the recycling stream, making the sorting process significantly more difficult and more expensive. Misleading information on food labeling has been a perennial public health issue [21]. In 1981 the World Health Assembly adopted an International Code to reduce inappropriate marketing and protect breastfeeding. The European Union and other countries have developed a set of mandatory elements for inclusion on food labels.

In the current study, we provided individuals with a picture of the symbol and asked respondents about their understanding of the symbol as well as their understanding of the numbers associated with the symbol. Prior research suggests that visual and text-based information is processed through divergent pathways, with visual stimuli processed more quickly and automatically compared with more controlled processing of text or written materials [22,23]. Hence, it was anticipated that the visual image would foster more automatic processing, which has been referred to as “System 1” processing. Within a dual-process framework, System 1 processing is automatic, triggered quickly and intuitively at a nonconscious level, while System 2 processing represents more deliberate, analytical, and effortful thinking. System 1 cognitions are driven by established mental pathways activated by stimuli, leading to quick inferences about the meaning of the symbol [24,25]. While System 1 processing is important in critical situations, it is also prone to subconscious cognitive biases. For example, inferences based on visual information are also more likely to lead to overconfidence about their meanings as compared with written materials [26]. In the present study, it was expected that there would be a high level of confidence in the assessment of the meaning of the symbol. It was also hypothesized that the symbol would lead to the conclusion that the object can be recycled, even though the image does not provide sufficient information for making such a judgment. However, it was expected that when asked for the more specific meaning of numbers associated with the logo, which required greater processing of information, most respondents would indicate that they have less knowledge of the meaning of the numbers on plastic containers.

2. Methods

The survey was part of an online longitudinal study of COVID-19, health, and well-being that began in May 2020. On the sixth wave of data collection, we included questions on knowledge of the meaning of symbols on plastic containers. The study recruited respondents from the MTurk online platform and followed best practices for MTurk studies,

including integrating attention checks throughout the survey, repeating study-specific qualification questions, and removing ineligible participants [27,28]. Eligibility included being age 18 or older, living in the United States, being able to speak and read English, having heard of the coronavirus or COVID-19, and providing written informed consent. Additionally, to enhance reliability, eligible participants had to pass attention and validity checks embedded in the survey. Following recommendations by Rouse and colleagues [29], we embedded checks to mitigate inattentive and random responding. These checks included survey questions with extremely low probabilities of occurring. We also repeated questions to ensure consistency. Finally, we examined the time participants took to complete the survey and verified the completeness of the data. Participants were compensated USD 4.25 for the sixth survey (14–23 June 2021), which was equivalent to approximately USD 12 per hour. The study protocols were approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

Measures: In the first question, we presented an image of a triangle comprised of three green mobius arrows (i.e., chasing arrows with a number in the center; Figure 1) Above the image was the question, “If you saw this image on a plastic container, what would it mean to you?” The response options were “It definitely can be recycled”, “It probably can be recycled”, “It most likely cannot be recycled”, “I cannot tell if it can be recycled”, “Other (please specify)”, and “Don’t know”. We also included two additional survey items; “When I see a number that refers to recycling on a plastic container, I usually don’t know what the number means”, and the statement: “A number less than 6 on a plastic container means that it can be recycled”. These items had the response categories, “Strongly agree”, “Agree”, “Neither agree nor disagree”, “Disagree”, and “Strongly disagree”.



Figure 1. Chasing arrows symbol.

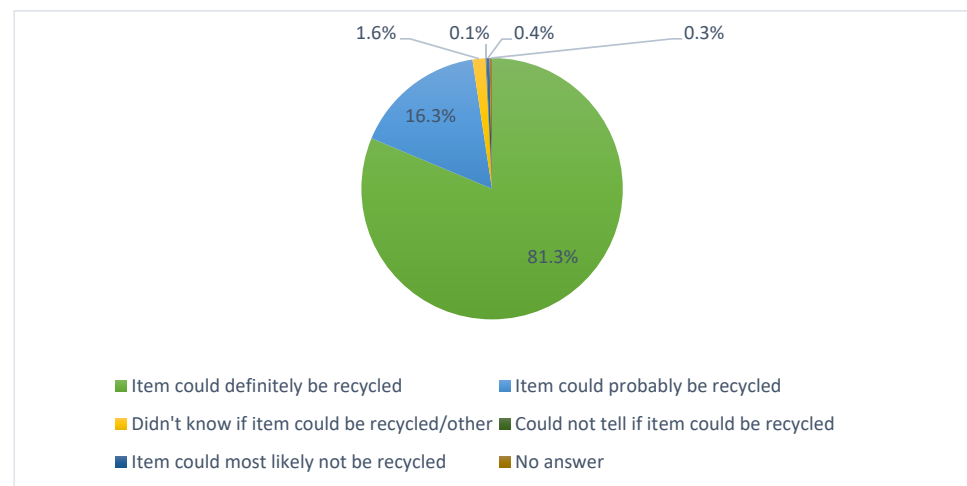
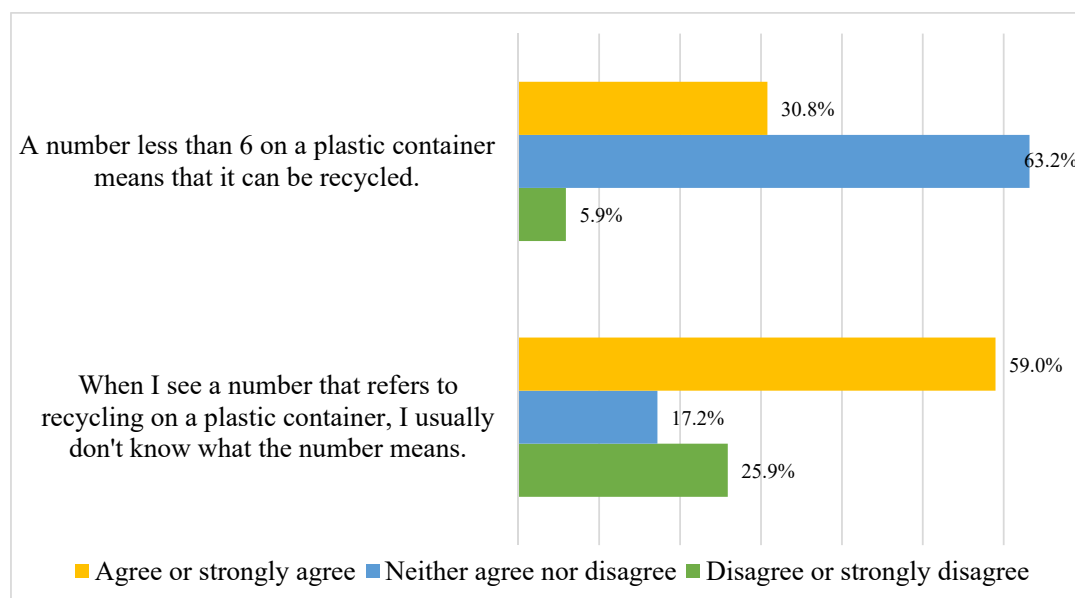
3. Results

There were 808 respondents who completed the sixth wave survey and passed the validity checks. As seen in Table 1, the majority were female (54.6%) and white (65.6%), with a smaller proportion identifying as Black (16.5%), Hispanic (9.1%), Asian (5.7%), or other (3.1%). Most of the sample had a bachelor’s (42.5%), followed by some college or a technical degree (29.2%), graduate education (16.1%), high school or less (12.2%), and most (55.8%) had an annual household income of less than USD 60,000. The median age was 38 (mean 40.3, SD = 12.07).

In response to the question about the chasing arrows image, 81.3% believed that it indicated that the item could definitely be recycled, 16.3% reported that it could probably be recycled (Figure 2), and 13 respondents (1.6%) reported that they did not know or provided an “other response”. Only one person (0.1%) indicated that one could not tell if the item could be recycled, and 5 (0.4%) respondents believed that most likely it could not be recycled. Interestingly, only 30.8% agreed or strongly agreed with the statement, “a number less than 6 on a plastic container means that it can be recycled” (Figure 3), whereas 63.2% neither agreed or disagreed, and 5.9% disagreed or strongly disagreed. In response to the statement, “when I see a number that refers to recycling on a plastic container, I usually don’t know what the number means”, 59% strongly agreed or agreed, 17.2% neither agreed or disagreed, and 25.9% disagreed or strongly disagreed.

Table 1. Demographic attributes of the respondents ($n = 808$).

	<i>n</i> (%)
Age	40.3 ± 12.07
Sex (Female)	441 (54.6)
Race	
White	530 (65.6)
Black	133 (16.5)
Hispanic	74 (9.1)
Asian	46 (5.7)
Other	25 (3.1)
Education	
Bachelor's degree	343 (42.5)
Some college or a technical degree	236 (29.2)
Graduate degree	130 (16.1)
High school or less	99 (12.2)
Household Income (<60 K)	451 (55.8)

**Figure 2.** Perceptions of the meaning of the chasing arrow symbol.**Figure 3.** Understanding of recycling numbers.

4. Discussion

The findings from this study suggest that due to the rapid processing of a visual and familiar symbol, the current symbols on plastics regarding recycling are misleading, with 98% believing that the triangular symbol, regardless of the referenced number, indicates that an object can definitely or probably be recycled. Interestingly, when the respondents were asked more detailed questions about the information provided by the numbers on plastics containers: most reported that they did not know the meaning, though almost one-third gave an inaccurate response.

This proportion of respondents who reported that the symbol indicates that the item can be recycled is in stark contrast with both the proportions of plastics that can be recycled in the US and the amount of plastic that is recycled. It is clear from this research that the recycling symbol leads to major misperceptions of container recyclability. The companies that manufacture these containers should be required to follow strict guidelines to reduce the false impression that all containers with these symbols are recyclable. Plastic container labels should provide easy-to-read information about the ease and feasibility of recycling them. Technologies such as QR tags and bar codes could also provide consumers and recyclers with additional information about the composition of plastic containers. In addition, most respondents reported that they did not know the meaning of the specific numbers on plastic containers. This finding is not surprising, as the ability to recycle plastics based on the number differs by locality and changes over time, with numbers 1 and 2 (out of 7) usually being recyclable. Regardless of whether respondents had inaccurate or incomplete information, these data suggest that the current labeling system is inadequate. As a majority of Americans report that they are taking action to protect the environment, inadequate information and access to effective plastic recycling may lead to frustration and guilt about recycling and potentially reduce self-efficacy to recycle [30].

Given the exceedingly low plastic recycling rates in the US [31], there is a need for systemwide changes and not merely additional education that places the burden on the consumer. Communities need the ability to be provided materials that can be easily recycled, adequately funded waste management systems that lead to recycling, and incentives that promote recycling. It is important to not only focus on the recycling of plastics. Key additional approaches to reducing plastic use and pollution are reducing use by substituting compostable materials, designing plastics for reuse, secure disposal of plastics, and reducing exports of plastic wastes [6]. One of the most promising methods to reduce plastics is through extended producer responsibility (EPR) legislation to ensure that plastic producers and brand owners reuse or recycle their plastic waste instead of shifting the blame to the consumers. In 2021, Maine became the first state in the US to sign EPR legislation into law for plastics and packaging materials. In addition to enacting EPR legislation, governments should provide guidelines for the symbols stamped on many plastic items since they are misleading many consumers in their current form. In the US, the Food and Drug Administration should consider banning misleading information about recycling on the packaging of food and drugs. More accurate labeling should include the information that most plastic items are highly unlikely to be recycled and that plastic waste can be toxic to humans and other living species.

The study's limitations should be acknowledged. The nonrandom sample limits generalizability. Moreover, we only presented one image to study respondents and did not present numerous different images of numbers within the triangle on plastic containers. Additional research is needed to understand factors associated with correctly understanding recycling symbols. This sample was younger than the average adult population in the US, and different generations may interpret the recycling symbol differently. As this study was only conducted in the US, it should be replicated in other countries and with respondents from diverse backgrounds. Future research should examine the impact of more accurate labeling on consumer behaviors, how to engage consumers in actions to reduce the gratuitous use of plastics in packing, and how to develop a more circular economy to reduce plastic pollution and greenhouse gas emissions.

Based on study findings, it is evident that additional training is needed for US residents to understand recycling guidelines. Children could receive school-based education on types of items that are recyclable and be encouraged to share this information with their families. Signs can be posted around refuse bins about how to read recycling symbols and which numbers on plastic containers are accepted in the given locale. Given the heterogeneity of recyclable items in the US as well as historical changes in item recyclability, residents may benefit from an easily accessible database, for example, a phone app that provides guidance on recyclable items in a specific area. Local governments can also post information on the recycling bins distributed to households on which items are recyclable in that jurisdiction. Finally, there is a need to standardize the recyclable symbol, as the chasing arrows do not always mean that an item is recyclable. In some US states, there are efforts to standardize these symbols through legislation, such as Senate Bill 343 in California (SB 343) [32].

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