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Beachgoer participation in prevention of marine litter: Using design for behavior change

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ABSTRACT

Much marine litter comes from land-based sources, with a significant amount coming from activities on bathing beaches. Thus, the overall focus of this exploratory research is to identify elements important for the design of beach infrastructure (i.e., trash cans (TCs)) to reduce littering behaviors. We base our investigation on principles of a relatively new approach, called Design for Sustainable Behavior. In doing so, we consider design for two user groups: bathing beachgoers and beach managers. We examined these users' perceptions of beach TCs through the use of an on-line survey of beachgoers, in-depth interviews with Israeli beach managers, a survey of international Blue Flag beach managers and a design 'ideation' workshop. Most importantly, we found that there is interest on the part of beach managers and other stakeholders in applying design principles to improve TCs. The findings of this study have implications for further interdisciplinary – and multidisciplinary – research on this topic.

1. Introduction

Marine litter damages habitat, endangers wildlife, impacts negatively on human health and the economy and destroys aesthetic qualities of beaches, making it one of the most pressing environmental problems of our time (see Bergmann et al., 2015). It can be broadly categorized as land-based or marine-based litter depending on whether it originates on land or at sea, respectively. The former comes mostly from agricultural, industrial and recreational activities whereas the latter originates mostly from fishing, boating and shipping (UNEP, 2009). Since bathing beaches are areas of intense recreational activities, most of the litter found on them is considered to be land-based (e.g., Hartley et al., 2018).

Estimates of the exact portion of marine litter originating on land vary somewhat, but are usually high when compared to portions originating at sea. For example, analysis of litter on beaches in Tasmania, Australia found that 77.5% had a land-based origin, compared with 22.5% from marine sources (Slavin et al., 2012). In general, a number of studies reported in Galgani et al. (2015) confirm that most of the marine litter sources are land-based rather than sea-based. Further, marine litter found on beaches, which may be up to 40% higher in the summer, consists primarily of plastics (bottles, bags, caps/lids, etc.), aluminium (cans, pull tabs) and glass (bottles), and found to originate from shoreline recreational activities (Galgani et al., 2015).

Regardless of exact percentages, it is clear that a significant amount of marine litter comes from land-based sources (Thiel et al., 2013; Hartley et al., 2018) and that recreational activities taking place on beaches have a major role in the generation of marine litter (Alkalay et al., 2007; Slavin et al., 2012; Laglbauer et al., 2014; Munari et al., 2016). Therefore, encouraging non-littering behaviors to address marine litter at its source (when it becomes litter) should be attempted in addition to any reliance on 'end-of-pipe' interventions, such as beach cleaning by employed cleaners or volunteers (Newman et al., 2016).

It is particularly important to curb littering behaviors by beachgoers in the Mediterranean Sea region where the bathing season is long, beaches are generally crowded and much litter is generated (European Commission, 2016; Munari et al., 2016; Pasternak et al., 2017). One of the earliest studies of marine litter along Israel's eastern Mediterranean concluded that most of the litter washed up on the beaches was left by users of the beach (Golik and Gertner, 1992). More recent studies of coastal waters in other parts of the world have led to similar conclusions (e.g., Mouat et al., 2010; Thiel et al., 2013; Galgani et al., 2015). This suggests that influencing beachgoer behavior is crucial. One way to do this, is of course, through education. However, this is not the only

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way to change behaviors, and due to the severity of the problem, additional means should be sought (Chen, 2015).

To address marine litter generated by beachgoers, this paper reports on research conducted to identify elements important for the design of beach infrastructure (i.e., trash cans) aimed at reducing littering behaviors. Since the focus is generally on infrastructure "design", this research is exploratory and largely qualitative in nature, keeping with traditions of the design discipline with its potential contributions to the environmental field, particularly for pollution control (Niedderer et al., 2017). In addressing the overall focus, this research uses a unique interdisciplinary approach, viewing infrastructure as a "product". Product design, including that of infrastructure in public spaces, invariably involves understanding users of the product being designed (Li-hsing, 2016). Two categories of users can be targeted for beach infrastructure design efforts related to litter: beachgoers and beach managers (Slavin et al., 2012; Munari et al., 2016; Pasternak et al., 2017; Portman and Brennan, 2017); therefore, this study aims to understand the needs of these two user groups.

After establishing the importance of experimentation with beach infrastructure design as a way to influence behavior related to beachgoer activity, we consider: a) potential contributions to reducing litter in public places using design for environmental behavioral change; b) findings of empirical research on beachgoers' perceptions of litter prevention on bathing beaches, and c) beach managers' constraints and needs for the management of beachgoer-generated litter. We present findings and draw conclusions from initial research that addresses beach managers' (both local Israeli and international) and users' perceptions and their behaviors with relation to trash cans (TCs) on beaches.

2. Current research leading to an interdisciplinary approach

Many studies have found that most beach litter is generated by beachgoers' littering behaviors (e.g., Slavin et al., 2012; Alkalay et al., 2007; Cingolani et al., 2016; Munari et al., 2016; Pasternak et al., 2017) and as such, previous research has asked: how can such behaviors be influenced? For example, Cingolani et al. (2016) investigated the effectiveness of messages in reducing littering behaviors among beachgoers in Argentina. They found that persuasive and demonstrative messages used simultaneously, respectively consisting of verbal requests to leave beaches clean and of showing beachgoers an example of non-littering behaviors, reduced litter by 35%.

Some past research has focused on questions about the adequacy of TCs and their role in preventing littering behaviors in public spaces generally, such as in parks and at train stations. However, with regard to the *structure and the look* of TCs, the focus has been on the use of messages attached to the receptacles (i.e., de Kort et al., 2008) or on the collection of a specific (albeit very important!) type of litter on beaches, i.e., cigarette butts (i.e., Widmer and Reis, 2010). With the exception of Wever et al. (2008), who found that larger TCs are needed to be effective in public parks at times of crowding (holidays, summer weekends, etc.), researchers have not specifically investigated TC structure and they have not incorporated the use of product design principles. As for general structural make-up of infrastructure other than TCs, a few minimally developed practices (such as litter catchment via nets and sieves (e.g., Armitage and Rooseboom, 2000)) have been developed. However, the users and "products" are different for these types of infrastructure than for TCs because they do not involve direct use by the general public.

From the literature, it seems that much about the impact and feasibility of overall product design for marine litter prevention has yet to be explored. Since Design for Sustainable Behavior (hereafter "DfSB") with its emphasis on product design directed towards environmental behaviors has developed recently (Niedderer et al., 2016, 2017), and since many of the studies on TCs in public spaces were completed beforehand, it is worth considering this approach to address the current and seemingly insurmountable problem of marine litter. DfSB as an exemplar approach that could potentially help influence behaviors related to the generation of marine litter from land-based sources. Since DfSB is based largely on information about user perceptions of their needs, exploratory research seeking such information is a first step in applying this approach.

2.1. Bringing fields together: product design, environment and behavior

The design of products is so ubiquitous that we barely notice that someone has likely thought long and hard about how a product can best serve us. In addition to being useful, product design shapes behavior which is ultimately a result of the choices made by product users (e.g., Gardiner and Niedderer, 2017; Clune and Lockton, 2018). Despite this having been an accepted fact for some time (see e.g., Lockton et al., 2010), research on the influence of design on behavior, often referred to as "design for behavior change", is in its initial stages. There are still only limited frameworks for testing its effectiveness in public contexts, such as for increasing and enhancing social norms, including environmentally-friendly behaviors (Spencer et al., 2013; Wilson et al., 2015; Niedderer et al., 2016).

Academic literature that addresses environmental behaviors and attitudes includes looking at aims and goals directed towards sustainable use of resources, i.e., "sustainability". Behaviors related to enhancement of sustainability are commonly termed "pro-environmental behavior" and considered preferable because they reduce environmental impact over the long-term, such as energy saving and recycling behaviors. Taxonomies of sustainability-enhancing pro-environmental behaviors differentiate between private and public behaviors (Schultz and Kaiser, 2012; Roczen et al., 2014). Private sphere environmental behaviors include those taking place at home and in one's personal life, such as behaviors related to water and electricity consumption, purchasing food, recycling, and driving to work. For the public sphere, two behaviors can be discerned: non-activist behaviors (e.g. signing petitions on environmental issues), and activist behaviors (e.g., active involvement in environmental organizations). Activist behaviors aim for general policy change that will affect the environment, such as a change in governmental taxes, public transportation and decisions regarding resource use (Stern, 2000).

In recent years, DfSB has been described as an "activist" approach to product design (Gardiner and Niedderer, 2017). It applies understandings from research on behavior and practice in ways that aim to reduce the environmental and social impacts of products, services and systems by moderating users' interactions with them through design (Bhamra and Lilley, 2015). Could DfSB also be applied to products that constitute infrastructure? Could DfSB be applied to the design of infrastructure products (i.e., trash cans), thus reducing the impact of waste on the environment? We posit that this approach can be applied in the realm of litter prevention for waste management and litter control.

A main phase in applying DfSB – that of design and development – involves selecting a behavioral target of where to intervene (Lilley et al., 2018). So far there has been some study of DfSB for interventions targeting particular types of environmental behavior and policy. For examples, Wilson et al. (2015) researched DfSB in case studies applied to reduce domestic energy consumption, and Spencer et al. (2013) researched the approach in cases related to laundry activities in the UK, India and Brazil. Additional literature related to DfSB includes Wever et al. (2008), Pettersen and Boks (2008), Oinas-Kukkonen and Harjumaa (2009), Lilley (2009), and Lockton et al. (2010, 2012, 2013). In some of these studies, different terminologies were used including design with intent, persuasive technology, and persuasive system design (Li-hsing, 2016). Based on these works, particularly Wever et al. (2008), Lilley (2009), and Lockton et al. (2013), the use of differently nuanced approaches at the design stage, depending on the type of "product" and behavior desired (e.g., *less* energy use or *more* trash can

use), can bring about change for sustainability and environmental protection.

2.2. Design and littering behaviors

Myriad strategies have been used to influence environmental behaviors and increase compliance with environmental norms (for reviews see Lehman and Geller, 2004; Schultz et al., 2013). To prevent littering, these strategies include community education, offering rewards and imposing penalties, increasing waste receptacles' availability, creating a commitment to enforce cleanliness rules and to maintain cleanliness of "adopted" places, as well as strategies that aim to reduce available litter through encouraging (or requiring) producers to use less packaging (source reduction), and to raise the value of debris through recycling and reuse (Durdan et al., 1985; Taylor et al., 2007, Ojedokun, 2011; Chen, 2015).

In some cases, a combination of attitudinal and structural interventions was found to be most effective (see Williams et al., 1997; Liu and Sibley, 2004) with the former referring to changing perspectives towards anti-littering and with the latter focusing on changes in the physical environment. Studies also show that an intervention's success depends on the type of littering (passive vs. active) and the type of item littered (Sibley and Liu, 2003; Liu and Sibley, 2004). Of note is Dwyer et al. (1993)'s research showing that antecedent interventions (i.e., strategies that prevent the occurrence of littering behavior) appear more cost-effective than consequence interventions (i.e., strategies that come after the fact, such as rewards or punishment). Overall, Huffman et al. (1995) found that both antecedent strategies and consequence strategies were effective in reducing litter. These findings make the case for influencing behavior as early on as possible at the source site, i.e., where the waste is littered in the public space.

To research the problem of litter in public spaces, Schultz et al. (2013) conducted research at the site level that provided coded observations of the littering behavior among 9757 individuals at 130 outdoor public locations in the United States. They found that the availability of trash receptacles negatively predicted littering. Furthermore, the presence of *existing* litter positively predicted littering and that among individuals who disposed of an item, distance to the receptacle was positively predictive of littering, thus reinforcing the importance of trash receptacles for litter prevention.

De Kort et al. (2008)'s study showed that littering norm activation could be influenced in different ways by using different messages on trash cans. This study included a scenario study, a field study and a survey. For the latter, the authors administered a questionnaire asking respondents about their perceptions of litter. Particularly relevant for the issue of infrastructure (product) design were the scenario and field studies which: 1) investigated the use of different TCs (showed to participants in pictures) and 2) observed actual littering behaviors (of 1755 individuals!) differentiated by signage and influential structural attributes. For the latter, they tested whether a mirror placed over the TC increased activation of the personal anti-littering norm.

Social norms, particularly important in public spaces, are considered either descriptive or injunctive (Liu and Sibley, 2004). A descriptive norm is what *is* typically done in a given setting, whereas an injunctive norm is what a particular culture approves or disapproves of (Cialdini et al., 1990). A third type, the personal (or internalized) norm differs from the social norm in that it is closely tied to how people perceive themselves, or in other words, the "self-concept" (Schwartz, 1975). Various studies conducted over recent decades in the fields of environmental psychology, social behavior and personality have shown that activation of a descriptive norm only reduces littering in a clean environment, and actually increases littering in a littered environment (e.g., Reiter and Samuel, 1980; Cialdini et al., 1990; de Kort et al., 2008; Schultz et al., 2013). This highlights the importance of keeping the beach clean. From the get-go, a clean beach is, in itself, a way to influence behaviors by iterative means; in other words, behaviors elicit continued similar behaviors. Persuasive design has often targeted personal norms (e.g., de Kort et al., 2008) and therefore should be relevant for beach TC design as well as for littering behaviors in general (e.g., Cialdini et al., 1990).

2.3. Influencing littering behaviors by design

Considering the deleterious nature of marine litter (Galgani et al., 2015) and the contribution of bathing beach activities to its generation (e.g., Slavin et al., 2012; Galgani et al., 2015; Portman and Brennan, 2017), it makes sense to examine whether approaches such as DfSB applied to TCs could help prevent marine litter. So far, it seems that experiments examining behaviors around litter prevention infrastructure, whether on the beach (i.e., Cingolani et al., 2016) or in some other type of public space (i.e., de Kort et al., 2008), have dealt almost exclusively with written or demonstrative messaging and then have used survey methods to see whether such interventions are persuasive enough to change behaviors.

Within the field of product design, Li-hsing (2016) developed a library that includes > 98 experiential cases that use some form of persuasive design. Cases matching certain conditions led to specific design suggestions. From this research, Li-hsing (2016) suggests a "domain knowledge model" that consists of five groups of attributes including target behavior, design principle, design technique, applicable technology, and user's motivation and ability. Users' motives and ability enhance the explanatory power of the model, especially when targeting specific users. When a trash can is viewed as the designed "product", the design elements will include principles, techniques and technologies. Incorporation of these parts of the model can replace or improve on previous attempts to influence TC users (and potential litterers) that included writing prompts on or above the TCs (e.g., Huffman et al., 1995; de Kort et al., 2008; Cingolani et al., 2016).

In one of the only studies focusing on TC design, Wever et al. (2008) describes what they call *functionality matching* for influencing littering behavior in public parks and which would impact the structural make-up (design) of TCs. Since they found that completely filled TCs in a public park caused people to leave their full trash bags beside them, the authors concluded that increasing capacity of frequently used bins, or clustering them, would thus be more helpful than simply increasing the number of bins. They refer to this as matching "functionality" of the TCs to observed behaviors. Other important design efforts aimed at littering behavior not specific to behavior in public spaces mentioned in the same study are supply side measures, for example the redesign of tabs on software cans to avoid their being littered.

Similarly, a focus on users' motives and ability highlights the importance of context for the application of DfSB (Clune and Lockton, 2018). Context is also emphasized in approaches to waste management and littering in particular (e.g., Cialdini et al., 1990; Williams et al., 1997; Arafat et al., 2007; Al-Khatib et al., 2009; Ong and Sovacool, 2012; Slavin et al., 2012; Brennan and Portman, 2017) and reinforces the need for local case study work. Furthermore, there is a significant disconnect between available theoretical knowledge of DfSB and its practical implementation (Gardiner and Niedderer, 2017). Reasons for this include a lack of awareness of the power of design and a common language for it. Also, evidence-based examples of design influence, evaluation methods and inter-sector collaborations that bring design to bear on major public needs, are in short supply (Niedderer et al., 2016). Therefore, we attempt to bring fields together; those of a) design, b) waste infrastructure planning and management, and c) coastal (public space) management.

Waste infrastructure planning and management in the coastal environment includes the TC, a product used by beachgoers and operated by beach managers. Whereas the motives of the first set of users (beachgoers) are clear – a receptacle for disposing of trash – the motives and abilities of the latter set of "users" are more ambiguous. They require the designer to consider the physical challenges characteristic of

the beach milieu: e.g., access and transport challenges, wave action, weather, maintenance, and of course budget related constraints. Therefore, it is the needs of these two groups that are explored here. The Mediterranean seacoast of Israel supports bathing activities as do most Mediterranean coastal communities. Considering the importance of Mediterranean bathing beaches to local economies, findings of this initial study will likely have some generalizable results.

3. Methods

Three surveys (detailed in Sections 3.1–3.3) and one design (ideation) workshop (detailed in Section 3.4) were used to explore how TCs can be designed based on beachgoers and managers' perspective of littering and trash collection infrastructure. For each of the three groups surveyed (and reported on in Sections 4.1–4.3), beachgoers, international beach managers and Israeli beach managers, a different survey instrument was used (all three are in Supplemental Materials, SM.1-SM.3). The questions appearing in each of these three surveys were developed based on what the research team was interested in knowing about managers' or beachgoers' behaviors, perceptions and preferences for litter collection on beaches specifically for the future design of beach TCs using DfSB principles. The last research stage (detailed in Section 3.4 and reported in Section 4.4) consisted of processing information gleaned from a design workshop (hereafter "ideation workshop"). The 15 attendees of this half-day workshop provided insights as to what TC designs would be most effective.

The workflow consisted of the three surveys used for: a) understanding the importance of TCs on the beach (to beach managers and users); b) general perceptions of them by beachgoers; and c) the importance of design elements (such as color, structure and function) as understood by beach managers coming from different contexts (i.e., countries). This corresponds with the chronology of the surveys' administration. The on-line survey and the Israeli beach managers' interviews were conducted simultaneously ((a) and (b) above). Then, the Blue Flag beach managers were surveyed (c above). The ideation design workshop was conducted two to three months later, once an understanding of the importance and salience of TCs had been confirmed.

3.1. Online questionnaire

The first stage of the research consisted of examining beachgoer perceptions of TCs and trash-related signage on Israeli beaches using a short internet questionnaire. This allowed us to determine how aware the public is to general TCs' physical design and to obtain respondents' opinions regarding cleanliness of the beaches (see Appendix SM.1).

The questionnaire, targeting random beachgoers, consisted of 11 questions and focused mainly on beachgoer waste disposal habits, TC visibility, and preferences for TC location on the beach. A link to the survey was sent via email and through various listserves of people who visit beaches, albeit at different frequencies. EcoOcean, an Israeli non-profit organization, helped distribute the survey. Established by a private philanthropic foundation and a group of scientists in 2002, EcoOcean has as its goal the preservation of the coastal and marine environment through research, education and broad community activities (see http://www.ecoocean.org).

3.2. Israeli Beach managers interviews

This survey was administered to solicit beach managers' opinions and needs with regard to TC design (see Appendix SM.2). It consisted of in-depth interviews conducted by two research assistants with the managers of the beaches of Tel Aviv, Netanya, Dor and Rishon LeZion. For these beaches, and in effect all those throughout the country, beach managers are employed by municipalities, or local authorities in rural areas. While they have to meet certain minimal national standards, these managers can make local-level choices with regards to waste management and beach cleanliness. The individuals chosen for in-depth interviews manage highly-used, crowded and popular Mediterranean beaches, three of them in very urban settings, and one of them (Dor Beach), is a popular, rural bathing beach.

The in-depth interviews used open-ended questions and provided data regarding problems faced by bathing beach managers in keeping beaches clean. We wanted to know what challenges they face in keeping these particular beaches clean and what concerns and preferences they had with regard to the TCs they use. For example, whether they preferred larger, more obvious TCs or smaller, more inconspicuous ones (see examples, including those used by the managers interviewed, in Fig. 1). The particular beach managers interviewed are known to the investigators heading up the project as dedicated to keeping their beaches clean and therefore, we assumed, would be willing to invest time in the long, arduous in-depth interview process.

3.3. Blue Flag representatives' survey

The third survey, consisting of a short one-page questionnaire, was administered to a group of international beach managers at a "Blue Flag" beaches[1] managers' conference. The Blue Flag program is operated under the auspices of the Foundation for Environmental Education headquartered in Copenhagen, Denmark. The annual meeting was hosted during two days in October 2017 by EcoOcean in the city of Netanya, Israel.

Since perceptions towards trash and littering is highly context dependent (e.g., Cialdini et al., 1990; Brennan and Portman, 2017), the results of surveys administered to Blue Flag beach managers from various countries were developed to provide insights about the general *design* aspects of the TCs, i.e., color, form and potential (hypothetical) image portrayed on the TC to attract beachgoers to use it. We sought information about the design elements of the TC, in particularly, which of these elements (i.e., color, shape, etc.) the managers would consider most effective based on their experience and cultural perspective.

With regard to the hypothetical "designs" of TCs, we asked respondents to rank which of two images of a sea turtle they thought would be more effective. Based on past work of de Kort et al. (2008), we presented one "implicit" and on "explicit" design (see Fig. 2). The former (implicit) design showed a sea turtle swimming on a natural-looking background only; the latter (explicit) design show an illustrated black silhouette of a turtle on a solid orange background with the written message "The beach is my home too" in three locally-used languages. The content of this survey, including pictures of the two prototypes, can be found in Appendix SM.3.

3.4. Ideation workshop

Developed based on the guidelines of previously held co-creative design "ideation workshops" (Heck et al., 2015) and refined for myriad types of products and situations (e.g., Ben Rejeb and Roussel, 2018), the workshop was held on December 20, 2017 at the offices of EcoOcean (mentioned above). Participants were hand-picked and invited to ensure representation of various types of stakeholders, i.e., beach managers, concerned citizens, NGO activists, educators and beachgoers.

The goal of the workshop was to establish which characteristics and features would be most important to include for the design of TCs on bathing beaches, while also raising awareness regarding the importance of beachgoer behavior with regard to marine litter. The discussions and exercises conducted during the workshop provided either general insights or specific ideas directed towards the design elements of the TCs (such as the collection bag, materials, particular visual images and

[1] "Blue Flag" Beach Program: an international beach rating program adopted by coastal municipalities to manage beaches and attract tourism (see Lucrezi et al., 2015).

Fig. 1. Examples of existing TCs on various designated bathing beaches in Israel (by city name): a) Rishon le Zion; b) Haifa; c) Caesarea; d) Olga; e) Netanya; f) Dor; g) Tel Aviv.

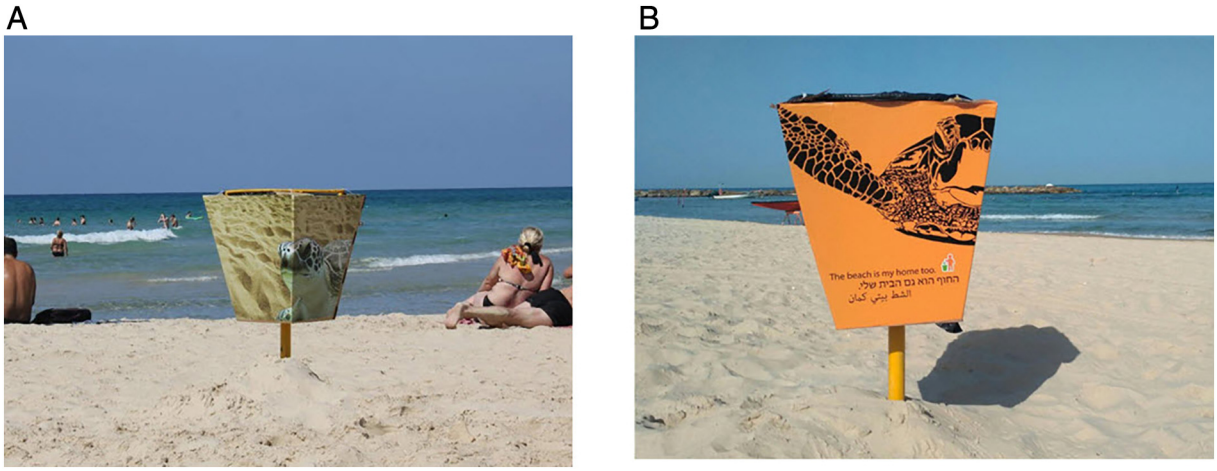

Fig. 2. Two Prototypes A (Implicit) and B (Explicit) included in the survey administered to Blue Flag beach managers. Note: the prototypes are the same size; the left-side photo (of A) is zoomed out to show more of the context within the frame.

texts) or catering to specific litter items (e.g., cigarette butts).

For the main exercise and following the above-mentioned guidelines (for such workshops; see Heck et al., 2015), four different typical users were described which are called “persona cards” in the design discipline. Participants were then split into four small groups. Each group had the task of designing a TC that would cater to the user assigned to that group. Ideas developed and presented by each group were then organized into categories and summarized. Analysis of the ideas included identify design elements that repeated themselves in several groups with the purpose of attracting beachgoers to make use of the TC. These ideas (see Findings below) will be used to design TCs prototypes for experimentation in the field.

4. Findings

This section reports on and summarizes the results of the qualitative information collected from the on-line questionnaire administered to random beachgoers, from the in-depth interviews conducted with beach managers and from the short survey administered to the Blue Flag conference attendees. It also explains what information was collected from the ideation workshop and how it was analyzed.

4.1. The online survey

The internet survey produced 159 responses over a two-month period (August–September 2017). Answers to the questionnaire provided additional insights about the beach users' perceptions of cleanliness, of TCs and of signage in general. From those who answered the relevant questions, nearly 63% noticed signage, which broke down to a little over 51.3% answering that there were signs and some (11.3%) responding that they noticed the lack of signage (37.3% did not notice whether there was or wasn't signage). To verify if people notice sign intent, our next question was “What signs have you seen on the beach?”. Exactly half of the respondents who reported noticing the signage were able to recall the signage's message. Out of those who noticed what signs say (n = 72), only 17 (23.6%) reported seeing signage related to littering and cleanliness. This suggests that few people notice anti-littering messages.

The questionnaire also asked about users' perceptions of TCs in general (i.e., whether or not they noticed the TCs) and about their perception of the relationship between the location of the TC and location at which they choose to sit at the beach. Slightly less than half (47.5%) reported wanting to sit as far as they could from a beach TC whereas slightly above half (50.6%) preferred to sit only a few meters from the TC.

As expected, results suggest a correlation between frequency of beach visitation and attention to the TCs. Approximately 64% of those who go to the beach 1–5 times per year, did not notice the TC compared to only ~7% of those who frequent the beach between 30 and 50 times a year or to barely 21.5% of those who visit 30–50 times or “as much as possible” (indicating generally > 30 visits a year). From among all visitors to the beach who answered the questionnaire, 33% indicated that they did not notice the trash cans.

An important finding involved responses to an open-ended question regarding the appearance of the bag within the TC (i.e., “How does the bag look?”). Approximately 17% of the respondents answered with a negative word or phrase (e.g., “bad” or “yuck”) or 20% when considering only those who answered this particular question. Some answered with a negative adjective or term about the bag, indicating some level of ineffectiveness (e.g., “full and torn” or “waving in the wind”). Others, from among those who answered (not included in the 20%) thought that the bag seemed to be doing its job or expressed neutrality regarding the aesthetic appearance of the bag, with answers such as “didn't notice” or “seems okay”.

4.2. Bathing-beach managers' interviews

The beach managers confirmed that the most commonly-used TC consists of a plastic bag secured by a metal frame supported by a monopole and buried as deep as possible in the sand (as shown in Fig. 1e). They explained that its advantages are: durability, low cost and ease of operation. A unique TC design was observed on Dor Beach, where large big orange bins are placed (as shown, for example, in Fig. 1f). During the in-depth interview, the Dor Beach manager explained that while the large bin accommodates more waste, it can only be emptied with a large vehicle. The manager that used this container reported receiving complaints from beachgoers about it blocking the sea view, but claimed that one of its advantages is that it stands out. With regard to bin location, some managers reported that TCs are most effective when placed along the water line, while others reported purposely scattering them unevenly further up-shore. All agreed that many TCs are needed; they generally placed the bins 5 to 20 m apart, adding more as needed at peak times, according to the season and day of the week.

The bathing beaches visited by the researchers display varying quantities and types of signage. Beach managers were reluctant, or more likely unable, to qualify the effects of signage on beachgoers other than to say that when it comes to separating waste, having clear and correct signs seems to be most effective. All of the beach managers brought up education as a key factor in litter prevention. One of the managers believes strongly in penalizing unwanted behavior and believes that greater enforcement has reduced waste and vandalism. The same manager observed that the amount of waste greatly diminished recently due to the prohibition of certain activities (e.g., beach barbeques). Of note, one beach manager believed strongly that education should take the place of TCs and that the absence of TCs altogether would be optimal. Managers also reported that cleanliness of the beach relates directly to budgetary issues, articulating their interest in obtaining more funding for keeping beaches clean.

4.3. Blue Flag beach managers' survey

Fifty-seven percent of the 60 participants at the Blue Flag Program Managers conference who were administered the study questionnaire answered (n = 34). Most respondents (91%) believe TC design can affect beach goers' behavior. When asked whether color or shape of the TC would be most effective, 71% indicated color, 18% shape, and 11% replied both. Most (68%) indicated that they thought the most effective color is green, followed by blue (13%) and yellow (10%).

From among the respondents, 85% agreed that one of our two prototypes would be effective in preventing beach litter, and 73% indicated that they would place either of the two TCs on their shores. Although Prototype A (implicit) was preferred by 62% of the respondents (and 94% would prefer to sit next to A and 68% would probably place it on their beach), the majority of respondents, (also 62%) thought that Prototype B (explicit) will attract more attention (see Fig. 3); 54% answered that Prototype A will likely be more effective in motivating the beachgoers on their beach(es) to properly dispose of their waste.

4.4. Ideation workshop

Comments about beachgoer littering behaviors, use of existing TCs and general discussion at the workshop, led to some concrete ideas for how to design different TCs than those currently used on the beaches (see Fig. 1). Two of the most frequently recurring general comments were those reinforcing the importance of considering the population character (i.e., language, nationality, age, etc.) and that any messages be encouraging and non-threatening or “preachy”. In short, positive interaction with the TC should be created. Also among the general insights, were those tailored towards experimental design. For example,

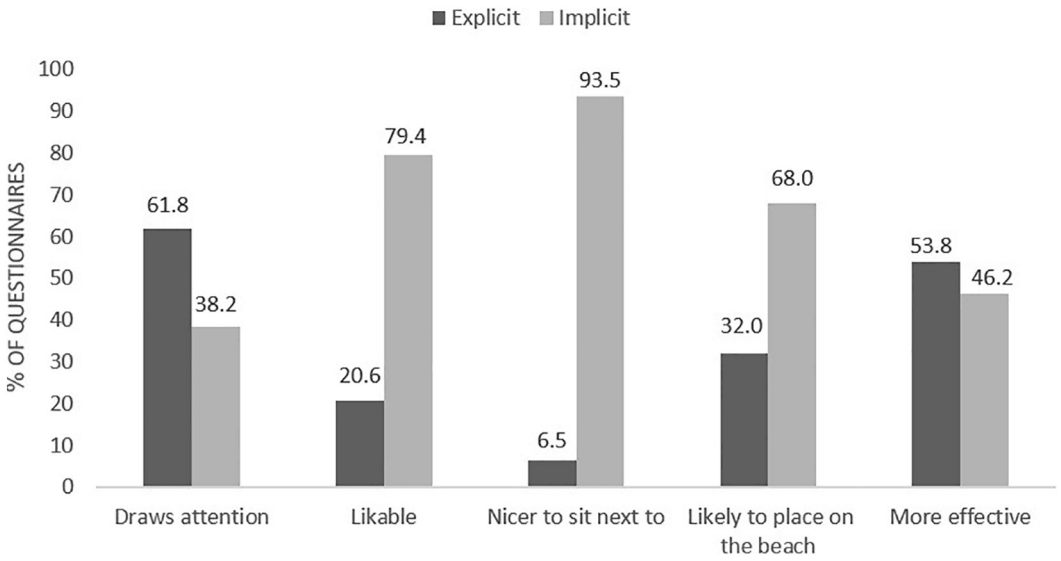

Fig. 3. Blue Flag beach managers' opinions of hypothetical Prototypes A and B (see Fig. 2).

the suggestion of creating similar prototypes that should have minor features differentiated between them.

With regard to elements, or features of the TCs, comments were grouped together and thus categorized (see Fig. 4). Categories consisted of: material characteristics (e.g., 'cheap to construct'); form; visual images; text; bags; interaction with user; apps (use of scanned bar codes or internet); cooperation with authorities; education and information. Some of the comments received, while providing the foundation for better understanding of the subject of litter and littering on beaches, would not be directly relevant for the design of TCs. For example, "giving out brochures instead of fines" or "there should be no TCs at the beach to encourage beachgoers to take trash with them". While these are good ideas, they can't be incorporated as part of TC design.

5. Discussion

To begin with, we reiterate the importance of, and need for, inter-disciplinary work that brings product design principles to the designing of beach infrastructure to address the problem of marine litter from land-based sources. As noted and highlighted in Section 2 above, there are only a limited number of studies that have tested the effectiveness of litter collection receptacles on beaches; one study investigated the effectiveness of portable beach ashtrays on bathing beaches in Brazil (Widmer and Reis, 2010) and another investigated the use of TCs on

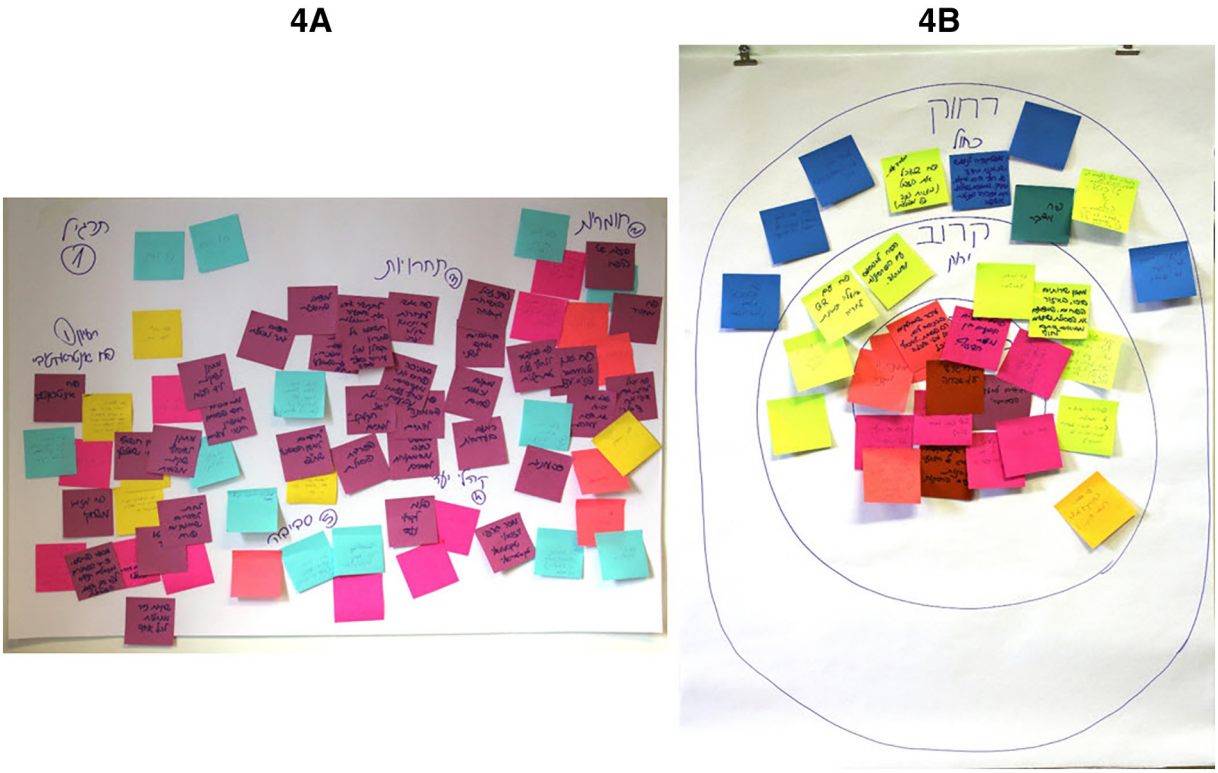

Fig. 4. Ideas from the "ideation workshop" organized by theme of "ideal" TC (4A) and by feasibility time-frame (4B). In 4B, sticky-notes closer to the center are feasible in the short term with those farther from the center (mostly blue), in the long term.

river beaches in Argentina (Cingolani et al., 2016). However, neither of these studied the application of design principles for changing littering behaviors in these areas. Our study's findings indicate a clear willingness and interest on the part of beach users and managers to take part in and to contribute to the design of beach TCs. Also, from the on-line survey, it seems that those who have clear opinions about design of TCs and notice existing TCs, are those who frequent beaches more often.

A paradox was detected regarding the relationship of the beachgoers to the TC which will likely have design implications. When TCs are set at close proximity to beachgoers, they are more likely to dispose of their waste; yet when there are too many bins and beachgoers have no choice but to sit close to a TC, there is some level of dissatisfaction. From the responses to the on-line questionnaires and from the survey of international beach managers (of the Blue Flag program), it seems that an attractive TC will not necessarily be an effective one. This will likely be the case in any public space where people are likely to linger for long periods of time (i.e., several hours at a time), such as in picnic areas or open-air concert venues where TCs can fill up quickly on certain days and times. Another important finding, emphasized also in the ideation workshop, was the preference for positive encouragement of the use of TCs, as opposed to negative "scolding" language and messages.

As mentioned above, Wever et al. (2008) applied design principles for keeping public parks clean. They highlight the use of a design technique referred to as *functionality matching*, which posits that designers should work with users' observed behaviors and build upon them so that design matches function or need, for example, creating larger bins based on observations of how park visitors place trash bags near an already full TC after picnicking in a forest park (Wever et al., 2008). In the beach environment, placing larger, more obvious TCs might annoy beachgoers; after all, the beach environment may involve more limited possibilities for siting than a large forest park. On beaches, visitors locate themselves at a preferred distance from an amenity, usually the water line. Also, as learned from the beach manager interviews, a larger bin (such as that in Fig. 1f) would involve the use of a large removal (emptying) apparatus instead of the collection bags via manual labor. The former is especially problematic during the height of the season when beaches are full and crowded.

These findings, based on information gleaned from the in-depth interviews, the two questionnaires and points brought up during the ideation workshop, suggest that imaginative and innovative product design could improve beachgoers' experiences while also enhancing litter prevention. Of note is that in the past when product design has been brought up in relation to marine litter, it connotes the design of wrapping or of disposable products in order to reduce or eliminate discards, and is sometimes referred to as "eco design" (Chen, 2015). Here the idea is different in that design is used to change behavior – i.e., persuasive design – in ways that will increase the use of the product, which in this case is the TC itself.

Trash cans that target particular behavior could be applied using relatively new methods such as Li-hsing's (2016) product design model. As mentioned, the model emphasizes incorporating targeted users and specific behaviors that inform design principles, design techniques, applicable technology, and users' motives and ability. Li-hsing applied the model to achieve more environmentally sustainability behaviors through products that focus on a lifestyle of health and sustainability (called "LOHAS" which involves combining environmental targets with healthy living styles, such as through the use of "eco-power" workout machines that both save energy and improve health). Such LOHAS-thinking could be broadened to include responsible citizen (personal) anti-littering behavior.

The work done within the framework of this study adds to the much-needed case-based body of literature on DfSB, called for by, for example, Li-hsing (2016) and Niedderer et al. (2016). It could also be used when applying DfSB principles for the types of litter known to be most common on beaches. For example, highly problematic on beaches in general, and in Israel in particular, are cigarette butts (Baztan et al., 2014; Pasternak et al., 2017); some innovative research using special collection receptacles for butts on beaches, as mentioned, has already been done (e.g., Widmer and Reis, 2010). This coincides with the fact that many comments were collected with regard to cigarette butts at the ideation workshop (see Section 4.4) suggesting that TC design should involve facilitating (or enabling) and motivating beachgoers to dispose of these waste items in particular.

In design studies, the term "enabling" refers to interventions that support people in making the right choices, i.e., "choices that lead to adoption of a healthier lifestyle and that fit their personal situation and preferences" (Ludden, 2018 p. 99). Findings from the four parts of this study could be used to identify interventions with the most potential to make a difference. Such strategies empower users to create their own plan of action and could be paired with Wever et al.'s *functional matching*, once we know what "personal situation(s) and preferences" are. Such product-user empowerment relates to how DfSB could be directed to myriad types of product design, including for infrastructure in the public space. "Users" in the present case are both beach managers and beach users. From the beach managers' perspective, physical challenges of the bathing beach milieu must be considered, including access to TCs for emptying them and for their maintenance over time, including responding to the effects of weather, salty and humid air, the potential for vandalism and budget-related constraints. From the beachgoers' perspective, attractive, inviting and enabling TCs are needed that should not block views or be too obvious.

Despite Cingolani et al. (2016)'s encouraging substantiation of the claim that persuasive and demonstrative messages can influence littering behaviors on riparian beaches in Argentina, they emphasize the need to deal with more than the proximate causes of the problem, i.e., littering behavior and the ultimate causes of waste at the source of its generation. An example is the prohibition of plastic bag use in grocery stores. Based on the expansive body of literature addressing marine litter, we suggest a multi-faceted approach and view the use of design principles applied to TCs as an *additional* means of addressing the problem, not the only one. Judging from the type of waste most commonly found on beaches (e.g., Golik and Gertner, 1992; Widmer and Reis, 2010; Portman and Brennan, 2017) design of products in general and their packaging should be encouraged in addition to implementing serious efforts towards better TC design.

6. Conclusions

The problem of marine litter is so complex that an interdisciplinary (and multidisciplinary) approach is needed to address it (Chen, 2015). This research shows that product design of beach TCs can be considered as part of the suite of solutions aimed at reducing marine litter from land-based sources. Application of design principles, such as those of DfSB, requires significant resources, as was learned in the different parts of this study (e.g., for the creation of prototypes that were asked about in the survey administered to the Blue Flag beach managers). We found significant interest in applying principles of design to the development of beach infrastructure on the part of beach managers and other stakeholders. Despite some evidence that product design could influence beachgoers' willingness to change littering behaviors and that beach managers are willing to try this route, the extent to which design can be successful is as yet unknown.

Findings of the initial research efforts described here in combination with relevant literature and knowledge provide a basis for further experimentation, particularly with DfSB. Such research could aim to identify the specific elements of beach TCs that would be most effective in influencing' participation in preventing marine litter through experimentation. This combined with various mixed (qualitative and quantitative) research methods, e.g., opened-ended interviews with more beach managers and empirical observation of beachgoer behaviors within their different contexts while using elements of the designs

discussed herein, can serve as a foundation for further work. Also, empirical research that explores the reasons that particular TC designs are currently used in specific places and why they have been chosen by beach managers would tell us more about the connection between beachgoer behavior and litter, and particularly, how this relationship is perceived.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2019.04.071.

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