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Review

Tackling the plastic problem: A review on perceptions, behaviors, and interventions

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HIGHLIGHTS

- Plastic pollution is a major global challenge.
- First comprehensive review on social-scientific literature related to plastic
- Gap between high problem awareness and plastic-related behavior
- Habits and social factors influence plastic-related behavior most.
- Political and psychological interventions are successful but understudied.

GRAPHICAL ABSTRACT

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ABSTRACT

The excessive production and consumption of plastic has serious consequences on the environment and human health. The reduction of plastic has therefore become a major global challenge. As technical solutions might be insufficient to curb the problem, a perspective highlighting the impact of human behavior is needed. The current literature review provides an overview of the existing social-scientific literature on plastic, ranging from risk awareness, consumers' preferences, and predictors of usage behavior to political and psychological intervention strategies. By reviewing the literature, we aim to identify potential factors for future interventions to reduce plastic consumption. The 187 studies reviewed show that people much appreciate and routinely use plastic, despite a pronounced awareness of the associated problems. Habits, norms, and situational factors seem to be especially predictive for plastic consumption behavior. Both political and psychological interventions are potentially effective, although long-term effects are often uncertain. The review closes with implications for behavior-based solutions and future research, which should combine interdisciplinary approaches and take into account cultural differences.

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Contents

1. Introduction

Today we live in an era that some have called the "Plastic Age" (Thompson et al., 2009b). The production of plastic has markedly increased over the last decades, currently reaching about 350 million tons per year (PlasticsEurope, 2018). Many advantages of the material, such as durability, flexibility, and cheapness, make plastic ubiquitous and indispensable in daily life, and thus it is distributed globally. However, there is growing evidence that the current use and disposal of plastic leads to substantial pollution of terrestrial and aquatic ecosystems (Bläsing and Amelung, 2018; Horton et al., 2017), already discussing plastic waste as a new planetary boundary threat (Galloway and Lewis, 2016; Rockström et al., 2009). Over 250,000 tons of plastic are estimated to float in the sea (Eriksen et al., 2014), adversely affecting marine wildlife and humans by plastic entering the food chain (Li et al., 2016; Rochman et al., 2016; Seltenrich, 2015; Sigler, 2014). In addition, the widespread use of plastic in agriculture has been postulated as a relevant source of soil degradation and microplastics (i.e., plastic particles smaller than 5 mm) in soil (e.g., Liu et al., 2014; Steinmetz et al., 2016). Furthermore, lab experiments demonstrate plastic to be a source of anthropogenic climate change as the most commonly used plastics might produce greenhouse gases when exposed to sunlight (Royer et al., 2018). Thus, plastic has a tremendous effect on various aspects of the environment, including wildlife, through diverse routes.

The most discussed risk to human health associated with the use of plastic is the exposure to harmful chemicals that are used as plastic additives (e.g., Hodson et al., 2017; Rist et al., 2018; Smith et al., 2018). Moreover, plastic particles may act as vehicles of persistent pollutants (Peng et al., 2017). The potential danger to human health might therefore arise from the uptake of food products that were in contact with plastic or contain microplastic.

As the entire production and application of plastic is of human origin, human solutions to the plastic problem are both necessary and feasible. Therefore, various societal actors (e.g., consumers, producers, policy makers, industries) need to be involved in the solutions (e.g., Löhr et al., 2017). Although a number of technical approaches of alternative materials or infrastructure have been developed to curb the problem (e.g., the production of biodegradable plastic or appropriate recycling procedures), there are two major obstacles: First, it is unlikely that technical approaches will solve the plastic problem comprehensively and in the required time. Second, there are well-known psychological effects that often undermine technical solutions, such as increased usage after an intervention (i.e., rebound effects; Hertwich, 2005) or increased littering of biodegradable products (Haider et al., 2018). Thus, efficiency strategies (e.g., recycling) can save resources at first glance but may eventually lead to a change in people's behavior as they consume more and thus reduce the resource savings. Moreover, technical approaches require people's acceptance, thus bringing additional factors into play. Hence, although technical solutions are definitively needed, a focus on human behavior is necessary to tackle the plastic problem from a multidisciplinary approach. To develop effective solutions, insights on perceptions, attitudes, and behaviors related to plastic is needed. As there is, to our knowledge, no compilation of social-scientific literature on the described issue, we aim at providing one that is useful for researchers and stakeholders.

2. Aims

In the current review, we provide an overview of the existing empirical social-scientific literature on human perception and behavior related to plastic use and disposal. Plastic is defined as a synthetic material composed of polymers. In the review, we did not give special attention to plastic additives, such as Bisphenol A, although they might affect risk awareness. Since the research field of plastic-related perception and behavior is relatively new and very diverse, the review is of a narrative nature. The main part of this review summarizes the studies and their findings. In the discussion, we integrate these findings to identify promising factors important for behavior-based solutions to the plastic problem and to reveal research gaps that future studies should address. This review, thus, provides both an overview of the existing literature helping to identify promising research questions, and useful information for practitioners and those developing interventions.

3. Methods

To identify relevant studies for the present review, we used several databases (PsychINFO, PsychArticles, Pubmed, and Web of Science). A first search using a set of keywords and their combinations (e.g., "plastic", "waste", "consumer behavior", "packaging", "recycling") led to an initial collection of studies. An article identified in the search was considered relevant if a) plastic was addressed as a material (ignoring other meanings, such as plastics in arts or plastic surgery), b) plastic was explicitly studied (and not just mentioned as an example or to specify the material of something that was not studied further), and c) attitudes, perceptions, or

behaviors were examined. The list of studies was then extended using a snowball strategy of searching backward and forward citations (Wohlin, 2014) and again applying the above criteria. Only articles published before September 27, 2018 were considered. The final pool comprised 187 articles that were included in this review. Fig. 1 shows the worldwide distribution of the samples described in the reviewed literature.

4. Results

Based on the literature found, we structured the review in three sections: problem awareness and perception of plastic (Section 4.1), plastic consumption behavior (Section 4.2), and solutions to the plastic problem (Section 4.3 and Discussion).

4.1. Perception of plastic

As outlined above, the increasing use of plastic has a severe impact on the environment and involves certain risks for human health. In the first part of this section, we review available literature on the awareness of such impacts. In the second part, we examine the perception of plastic in the context of consumption. Knowledge about problem awareness and preferences helps to identify predictors of plastic consumption behavior and thus leads to potential starting points for solutions. Note that within this chapter, perceptions were described and that these may not be in line with the real circumstances (e.g., the perceived environmental impact might diverge from the actual one).

4.1.1. Problem awareness

4.1.1.1. Perceived impacts of plastic pollution on the environment. Plastic used as a material for packaging and bags is generally seen as environmentally problematic (e.g., Adane and Muleta, 2011; Fernqvist et al., 2015; Otsyina et al., 2018; van Dam and van Trijp, 1994). Furthermore, in social media "plastic" is discussed and associated with "sustainability" and "waste", indicating certain problem awareness (Richardson et al., 2016). In an earlier Danish study (Bech-Larsen, 1996), environmental problems due to (packaging) waste were considered as less serious compared to other societal and environmental issues. However, as might be expected by the increased use and disposal of plastic ever since, more recent and large-scaled surveys conducted on citizens in several countries (e.g., Portugal, UK, Germany, Canada, Kenya) show that pollution in general and plastic waste in particular are perceived as major environmental problems (Gelcich et al., 2014; Hartley et al., 2018b; Lotze et al., 2018). The immense use of plastic (esp. in packaging) and related human behavior are perceived as significant causes of pollution (Hartley et al., 2018b; Santos et al., 2005). In fact, problem awareness is already high among school children from different countries (United Arab Emirates: Hammami et al., 2017; UK: Hartley et al., 2015; Hong Kong: So et al., 2016). Plastic litter is highly abundant at most coastlines worldwide and often beach visitors and locals are perceived to be the source of such litter (Beeharry et al., 2017; Brennan & Portman, 2017; Campbell et al., 2016; Hartley et al., 2018b; Kiessling et al., 2017; Rangel-Buitrago et al., 2018; Santos et al., 2005). However, the amount of former fishing and aquaculture utensils (e.g., fishing lines, buoys, pipes) made from plastic is also very high both in the sea and at beaches, and this debris is perceived as a major threat for marine wildlife, boats, and humans (Barnett et al., 2016; Pearson et al., 2014). Additionally, plastic waste is perceived to negatively affect terrestrial animals (Adane and Muleta, 2011; Otsyina et al., 2018).

Although microplastic has become a hot topic in media and environmental science, social-scientific studies on the perception of microplastic and its risks are rare to date. By definition, such plastic particles are small and thus difficult to see and retrieve from the environment compared to macrodebris (cf., Barnett et al., 2016, for such an observation by Candian fishermen). Interviews with beauticians, students, and environmentalists show that only the latter were aware of microplastics in facial scrubs (Anderson et al., 2016). The majority of participants indicated awareness that these particles will go into the ocean after use. After participants of this UK study were made aware of these issues, they reported environmental concerns, especially risks for marine fauna. However, for them these environmental problems are not as pressing as others (Anderson et al., 2016). Overall, (macro- and micro-) plastic is generally seen as an environmental hazard, though to a varying degree.

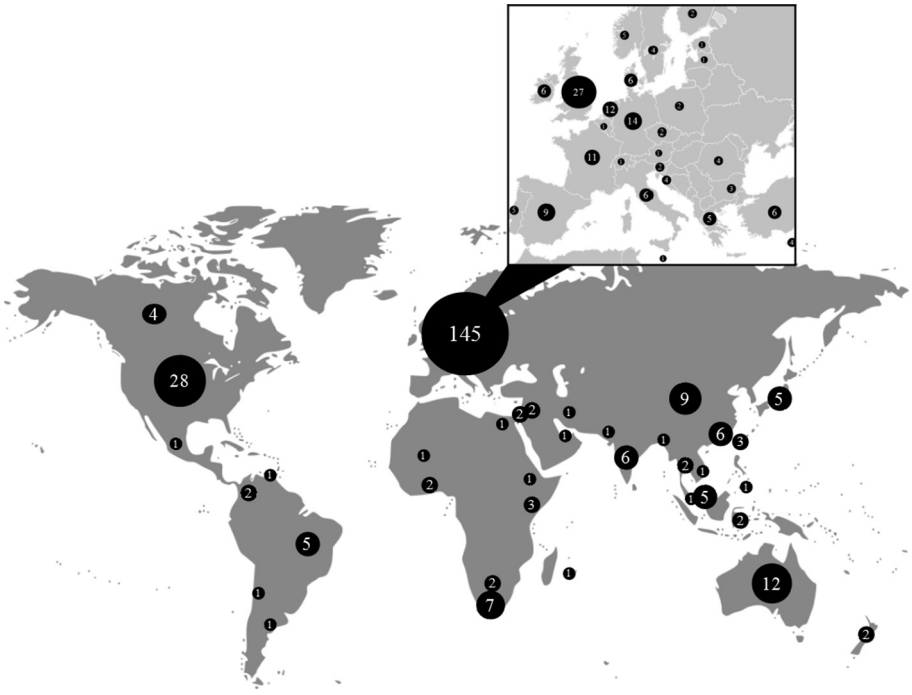

Fig. 1. Countries represented by reviewed studies. Numbers indicate amount of studies investigating a sample from a particular country (several countries per article possible; same original sample might be counted repeatedly when presented in different articles). One article (Clapp and Swanston, 2009) was excluded because no sample was investigated.

4.1.1.2. Perception of human health and well-being risks. Besides the perceived environmental risks, people are concerned about hazards related to their health and well-being. For example, litter is associated with reduced preference for and perceived restorative quality of a given place and this is especially true when the litter originates from the general public (e.g., plastic bottles) compared to fishing-related litter (e.g., fishing ropes; Ballance et al., 2000; Kiessling et al., 2017; Wyles et al., 2016). Furthermore, potentially health-threatening litter items (e.g., syringes and condoms) were perceived as more offensive than other beach litter (Tudor and Williams, 2003). In general, coastal scenic quality seems to be negatively affected by the amount of (plastic) litter but it is noted that this appeal might be restored by beach clean-ups (Corraini et al., 2018; Rangel-Buitrago et al., 2018; Williams et al., 2016), which are being carried out with increasing frequency nowadays (e.g., Loizidou et al., 2018; see also Section 4.3.2.3 for more information on clean-up interventions). In a Spanish study, beach litter was perceived as higher the more plastic was seen and the more often one visits the beach (Rayon-Viña et al., 2018).

Although the beaches investigated in an Australian study were relatively clean, about 22% of beach goers experienced injuries (e.g., small cuts) from litter which mainly consisted of plastic items (Campbell et al., 2016; see also Santos et al., 2005, for similar results). The majority of respondents, however, did not perceive plastic litter as a human (but rather an environmental) hazard, and previous injuries did not affect the perception of litter (Campbell et al., 2016). However, in a similar – but older – study human risks were rated higher than or similar to environmental hazards (Santos et al., 2005). The difference between these two studies might illustrate the increased awareness of the environmental hazards described above.

Although US consumers of facial scrubs considered the products safe to use, most of them deny purchasing or using it when confronted with the fact that it contains plastic (Chang, 2015), and others reported both health (related to the skin while using the scrub and accumulation in the food chain) and environmental concerns (see above, Anderson et al., 2016).

Consumers from different countries (Turkey, Sweden, India, and Ghana) expressed concerns about health-affecting properties of plastic, such as harmful substances in plastic and reduced food quality due to the packaging (Aday and Yener, 2014; Fernqvist et al., 2015; Joseph et al., 2016; Omari and Frempong, 2016; Omari et al., 2018). However, compared to cans made from metal, plastic is perceived as safe (e.g., Peters-Texeira and Badrie, 2005). In fact, compared to glass bottles or cans made from metal, plastic is reported to cause less injuries when opening a package (Caner and Pascall, 2010). In a Ghanaian study, the degree of worry about leaking substances from plastic packaging into food is similar to other chemical-related risks, such as those from pesticides or artificial coloring (Omari et al., 2018). While the majority of participants from a Hawaiian study on plastic alternatives preferred microwavable containers for takeout food (Barnes et al., 2011) other participants of a Swedish study reported concern related to plastic food packages designed for microwave use (Fernqvist et al., 2015). Additionally, plastic bag use is associated with health risks that were not further specified in an Ethiopian study (Adane and Muleta, 2011). Not only were consumers worried about potential health hazards of plastic but regulatory officials were also concerned and uncertain as pointed out in an UK case study (Rothstein, 2003). In general, the risk perception of plastic (pollution) has changed within the few last decades and some characteristics of plastic (e.g., its highly abundant and thus involuntary exposure, unnecessary use, and uncontrollable spread) have led to high risk perception (Syberg et al., 2018).

4.1.2. Consumer perceptions

Much of the plastic waste found in the environment consists of food-related packaging, including bottles, bags, and eating accessories (e.g., Carpenter and Wolverton, 2017; see also Marsh and Bugusu, 2007). Moreover, one third of the worldwide plastic production is for packaging (PlasticsEurope, 2017). Therefore, knowledge about the perception and preferences of consumers is necessary to tackle the plastic problem.

4.1.2.1. Perception of the environmental impact of plastic packaging and bags. Packaging fulfills a number of functions, including protection of the product and communication of product characteristics (as reviewed by Lindh et al., 2016b; Marsh and Bugusu, 2007). Although the product itself and other aspects of production and transportation usually have a larger impact on the environment than the packaging per se (Jungbluth et al., 2000; Wikström et al., 2014, but see also Pasqualino et al., 2011), unsuitable packaging increases the amount of food waste and therefore packaging should be appropriate to reduce environmental impacts (e.g., Silvenius et al., 2014; Williams et al., 2012). For example, when Norwegian consumers were unsatisfied with the packaging, they may use their own plastic bag to maintain the freshness of bread and thereby reduce food waste (Østergaard and Hanssen, 2018).

Although appropriate packaging is important for the protection and environmental impact of a product, its material plays only a minor role in the preference of one product over another (Eldesouky and Mesías, 2014; Gelici-Zeko et al., 2013; Silayoi and Speece, 2004, but see also Rokka and Uusitalo, 2008, for different results when recyclability of the material was made salient for the choice, and also Widaningrum, 2014, for divergent findings). Other properties of the product or package, such as price, visual and functional aspects of the package, size, and previous experience with the product or brand are rated as more important (Draskovic et al., 2009; Eldesouky and Mesías, 2014; Gelici-Zeko et al., 2013; Isa and Yao, 2013; Koutsimanis et al., 2012; Peters-Texeira and Badrie, 2005; Scherer et al., 2017; Silayoi and Speece, 2004; Young, 2008). When directly asked about the packaging material, respondents of a study from Thailand stated in interviews that it should be non-toxic, convenient, and prolong high product quality (Silayoi and Speece, 2004).

The negative environmental impacts of plastic packaging are considered disadvantageous (Aday and Yener, 2014; Fernqvist et al., 2015). Plastic-only packaging was ranked medium for environmental friendliness by both Dutch consumers and a life cycle analysis (Steenis et al., 2017). In the same study, bioplastic (which was not specifically defined) and glass were rated as especially sustainable by consumers, while a life cycle analysis ascertains that carton and mixed carton-plastic packages are more sustainable in the example of a soup package. Similarly, respondents of other studies rated glass (and sometimes also paper-based materials) most environmentally friendly, while plastic and metal were rated most negative (Lindh et al., 2016a; van Dam, 1996). Note, however, as mentioned in van Dam (1996, p. 612) that "consumers judge environmental friendliness only from their beliefs concerning the post-consumption treatment of the packaging waste", and therefore consumer perception and results of life cycle analyses may diverge (e.g., Jungbluth et al., 2000; Steenis et al., 2017; van Dam, 1996; Wikström et al., 2014).

In line with this focus on post-consumption, consumers focus more on recyclability, biodegradability, and reusability than on the origin of the raw material when evaluating the environmental friendliness of a material. However, there were also differences among the different nationalities investigated (Germany, USA, and France; Herbes et al., 2018). Recyclability of the package is generally perceived positively and in experimental studies consumers were willing to pay more for a product with recyclable (plastic) packaging material (Barnes et al., 2011; Klaiman et al., 2016; Rokka and Uusitalo, 2008; Vones et al., 2018; Young, 2008). However, recyclability of the package is rarely a reason to buy a product (Aday and Yener, 2014; Koutsimanis et al., 2012; but see Rokka and Uusitalo, 2008). This might have various reasons as, for example, post-consumer recycling is sometimes perceived as difficult (e.g., Venter et al., 2011) or impossible (Li et al., 2010). The need to clean a package hinders people from recycling a package (irrespective of material; Klaiman et al., 2017). Furthermore, the environmental

attitudes of consumers affect their perception of a packaging made from recycled materials as was indicated by an experimental study showing that French participants with low environmental concern perceived it negatively (i.e., as 'green washing') when there was a claim "made from recycled material" on a plastic bottle compared to an ecologically looking non-plastic bottle (Magnier and Schoormans, 2015).

Generally, biobased materials (i.e., made from plant or other renewable material; irrespective of biodegradability) were preferred over conventional plastic (Kainz et al., 2013; Koutsimanis et al., 2012; Magnier and Schoormans, 2015, 2017). Similarly, biodegradable materials (i.e., degradable with the help of microorgansims and/or sunlight) were also preferred over conventional plastic and people may be willing to pay more for it (Muizniece-Brasava et al., 2011; Yue et al., 2010). The preference for biodegradable and other (seemingly) environmental friendly materials might be due to the perceived advantages of reduced pollution and health hazards (Magnier and Crié, 2015). However, a Romanian study indicated that biodegradable plastic (compared to paper, cardboard, or glass) was rated as the least preferred environmentally friendly packaging material (Orzan et al., 2018). This discrepancy highlights that consumers lack knowledge about the properties of both biodegradable and biobased plastic (Kainz et al., 2013; Koutsimanis et al., 2012; Mohamed, 2015). For example, consumers confound characteristics of bioplastic (i.e., biobased) and biodegradable materials and thus have incorrect associations to them (Blesin et al., 2017; see also Young, 2008, for similar findings on recyclability vs. recycled source material). The lack of knowledge might furthered derived from the facts that those materials are both rarely in use and its environmental effects were understudied so far (Rujnić-Sokele and Pilipović, 2017; Spierling et al., 2018). Relatedly, a Bangladeshi study by Synthia and Kabir (2015) showed that characteristics of plastic alternatives were unknown and the authors highlighted the need for more education when banning plastic products. Their study revealed that after a ban of certain plastic bags, new alternative bags (e.g., net, nylon, or polyethene bags designed differently to the banned ones) were used increasingly and considered more environmentally friendly although the latter was not always true.

4.1.2.2. Perceived advantages of plastic packaging and bags. Preference for plastic as a packaging material is based on its functional aspects (e.g., Bech-Larsen, 1996). Several studies from all over the world showed that plastic is preferred due to its convenience, light weight, transparency, resistance, option for resealability, as well as hygienic and protective properties (e.g., Aday and Yener, 2014; Drašković, 2010; Drašković and Cerovečki, 2014; Draskovic et al., 2009; Hollywood et al., 2013; Phillips, 2016; Venter et al., 2011). The consumers' perception of these advantages is in line with those of Croatian employees of a soft drink company and Australian salespersons (Drašković, 2010; Phillips, 2016). For bags, plastic is the preferred material, because such bags are perceived as convenient, easily available, waterproof, and cheap (Adane and Muleta, 2011; Madara et al., 2016; Musa et al., 2013; Negussie and Mustefa, 2017; Nittala, 2014; Prendergast et al., 2001).

4.1.2.3. Packaging preferences depending on contextual factors. Although plastic is generally appreciated for several advantages (see above), preference for a certain packaging differs depending on several factors, such as the product category. For example, fruits and vegetables are preferred to be bought loose without any packaging (Ali and Kapoor, 2008; van Herpen et al., 2016). If participants were asked to choose between several materials for fruit and vegetable packaging, they preferred biobased and degradable materials (e.g., cotton or paper) over conventional plastic (Ali and Kapoor, 2008; Fernqvist et al., 2015; Koutsimanis et al., 2012). These findings are in contrast to the approach used by many supermarkets. When Danish consumers were asked to rate different packages for fresh carrots (plastic bag, plastic or cardboard box with plastic foil), they preferred the boxes over the bag due to higher perceived value and quality (and thus favoring over-packaging; Nørgaard Olesen and Giacalone, 2018). The majority of these respondents mentioned the transparency of the packaging as most important, while environmental friendliness was only mentioned by 15% of the participants. Note that these results were not compared to no packaging. Willingness to pay for less packaging of shampoo was rather low (Yamaguchi and Takeuchi, 2016). Thereby, the motivation to buy a refill-shampoo bottle was mainly a price argument rather than concern for the environment. In addition, these Japanese participants perceived refillable bottles as unsightly or troublesome when reusing them (Yamaguchi and Takeuchi, 2016).

When explicitly confronted with different kinds of cheese packages, Spanish consumers preferred plastic – mainly because of its transparency (Eldesouky et al., 2016; Eldesouky and Mesías, 2014; see Peters-Texeira and Badrie, 2005, for a similar result on fruit preserves). However, some consumers indicated in a word completion task a disfavor of a particular cheese when packed in plastic, likely due to perceived overpackaging and hence its contribution to pollution (Eldesouky et al., 2015). Additionally, Malaysian consumers preferred vinegar in glass rather than plastic bottles although they liked plastic lids more than metal ones (Latiff et al., 2018). For milk and other cold chain products, plastic (and glass) bottles or Tetra Briks (i.e., typical cuboid plastic-coated carton of the Tetra Pak company) with a cap were the preferred packaging materials (Gómez et al., 2015; Hollywood et al., 2013; Van der Merwe et al., 2013; but see also van Dam and van Trijp, 1994, for divergent findings when consumers were asked for perceived environmental friendliness). However, as indicated above, packaging preference depends partly on the context. For drinks, plastic bottles are preferred generally, and especially on the go, but clearly not in the context of cafés and restaurants where glass is preferred, as was suggested by Croatian studies (Drašković, 2010; Drašković and Cerovečki, 2014; Draskovic et al., 2009).

Besides the described contextual and product-related factors, the consumers' cultural background, age, and environmental attitude influence preferences for plastic as a packaging material (e.g., Draskovic et al., 2009; Lal et al., 2015; van Dam and van Trijp, 1994; see also below in Section 4.2 for predictors of plastic-related behavior).

4.1.2.4. Priming effects of plastic. The material of a package provides more than its functionality; it also affects the consumers' perception of the product and subsequent consumption. For example, plastic packaging is associated with different characteristics of the product such as higher (compared to carton) or lower (compared to glass) hygienic properties (Drašković and Cerovečki, 2014; Venter et al., 2011). Some Croatian and South African consumers perceive products packed in plastic as relatively expensive and assume retained food quality, while others associate it with being cheaper and of lower quality (Drašković and Cerovečki, 2014; Venter et al., 2011). The product itself is perceived as more environmentally friendly when packed in biobased material compared to a plastic alternative as suggested by a French study (Magnier and Schoormans, 2017). Another French study showed that while overpackaging seems to be associated with better quality of the product, it is also perceived as environmentally unfriendly (Elgaaïed-Gambier, 2016).

Besides these more general associations evoked by the packaging, it directly affects the taste and quality of a product. Croatian consumers stated that plastic negatively affects the taste and quality of carbonated drinks due to gas migration (Draskovic et al., 2009). Furthermore, the material of eating utensils influences the perception of a product, whereby plastic is often perceived as less favorable compared to other materials (Piqueras-Fiszman and Spence, 2011; Schifferstein, 2009; Spence and Wan, 2015; Tu et al., 2015). In addition, tactile perceptions differ between plastic and other bottle materials (Lefebvre et al., 2010).

Moreover, waiving plastic consumption by bringing one's own shopping bag instead of using offered plastic bags affects subsequent behavior by priming (i.e., buying organic food) or licensing (i.e., buying indulgent products) effects, as was shown by an US study (Karmarkar

and Bollinger, 2015). Relatedly, an Indian study showed that positive attitudes towards plastic bags negatively affect the willingness to buy environmentally friendly products (Nittala, 2014).

4.2. Plastic-related behavior and its antecedents

Despite high awareness of the problem, usage rates of plastic products such as bags are generally high (Arı and Yılmaz, 2017; Musa et al., 2013; Shao et al., 2014; Sharp et al., 2010; see also Section 4.1). When investigating the relationship between awareness and behavior explicitly, awareness of harmful effects of plastic had no effect on usage behavior (Hammami et al., 2017). To identify predictors of plastic-related behavior, we review studies that investigated possible predictors for the consumption, avoidance, and waste behavior related to plastic.

4.2.1. Factors influencing plastic consumption behavior

4.2.1.1. Sociodemographic variables. Gender differences were reported for plastic bag use in a study by Hohmann et al. (2016), though without specifying in which direction. Other studies reported in more detail that women were more willing to accept and apply alternatives to plastic bags than men (Madigele et al., 2017; Ryan and Jewitt, 1996; Sharp et al., 2010), and showed overall more practices of reusing, reducing, and recycling than men – as do older people in most cases (Kurisu and Bortoleto, 2011).

Older participants were more likely to participate in a no-plastic-bag-campaign (Afroz et al., 2017). In contrast, a study on overpackaging showed that younger participants were more willing to give up their convenience in order to help the environment (Elgaaïed-Gambier, 2016). A Croatian study reported that younger participants favored plastic and carton bottles over glass and metal, while older participants were not concerned about the packaging material during purchase (Draskovic et al., 2009).

Higher educated people were less willing to pay for plastic bags (Madigele et al., 2017) and more likely to participate in a no-plastic-bag-campaign (Afroz et al., 2017), thus showing stronger plastic avoidance than less educated people.

4.2.1.2. Environmental attitudes. People (esp. women) with higher environmental attitudes and education stated that they more often avoided disposable plastic packaging (Jeżewska-Zychowicz and Jeznach, 2015). Food-related environmental attitudes were also associated with avoiding plastic packaging and bags (and thus bringing one's own bag more often; Lea and Worsley, 2008). Notably, in another study on reusable bags, social desirability significantly predicted environmental attitudes (Yeow et al., 2014). Therefore, it is always advisable to take social desirability into account when looking at self-reported plastic-related behavior (see also below in Section 4.2.1.7).

4.2.1.3. Convenience. As outlined in Section 4.1.2.2, convenience is associated with plastic. Convenience is also a main reason for plastic bag usage (Braun and Traore, 2015) with respondents especially emphasizing easy availability and low price of such bags (Adane and Muleta, 2011; Otsyina et al., 2018). Similarly, having no alternative option at hand was the most frequently reported reason for using plastic bags (Avallone et al., 2012). Convenience outperformed the classical factors of the theory of planned behavior (i.e., attitudes, subjective norms, and perceived behavioral control; Ajzen, 1991) by being most strongly associated with the intention of using plastic bags (Sun et al., 2017). Relatedly, alternatives to plastic products (e.g., zero packaging grocery stores) were seen as inconvenient and thus rendering the plastic option more attractive (Beitzen-Heineke et al., 2017).

4.2.1.4. Context factors. Generally, the perceived advantages of plastic products seem to be more important than other psychological variables at the moment of making a decision as was indicated by a Taiwanese study on plastic bags (Lam and Chen, 2006). While both buying and reusing intentions were related to attitudes, environmental concern, and personal norms, the actual purchase behavior was not correlated with such psychological variables. Instead, only situational variables (e.g., the amount of goods being greater than expected) had predictive value (Lam and Chen, 2006). Notably, here the perceived advantages of using plastic bags are probably not inherent to plastic itself but rather due to its availability compared to alternatives. In other conditions, specific characteristics of plastic were reported to be more relevant (e.g., transparency of plastic packaging; Nørgaard Olesen and Giacalone, 2018).

4.2.1.5. Habits. Additionally and related to convenience, habits are important for plastic consumption. In a study on Brazilian immigrants in Canada, the participants indicated that plastic usage in their homeland had been "just a habit" (Romero et al., 2018, p. 8). Having moved, they changed their behavior by showing greater plastic bag avoidance and waste separation (Romero et al., 2018). Notably, pro-environmental attitudes remained unchanged throughout the process of habitual change (Romero et al., 2018). Changed norms and/or external conditions might have facilitated a change of habits in this case (see also below in Section 4.2.1.7), which highlights the importance of cultural factors for the emergence of habits.

Even when participants were willing to reduce their plastic consumption, they partly failed because they were not able to apply new habits, as was suggested by two studies in which the most common reason reported for the use of plastic bags was forgetting to bring one's own bag (Bartolotta and Hardy, 2018; Musa et al., 2013). Similarly, in a Malaysian study on a plastic-free-day-campaign, about 60% of the respondents regularly forgot to bring their own bags during the campaign (Zen et al., 2013).

4.2.1.6. Diffusion of responsibility. Another reason that consumers do not act in line with their risk perception might be that they shift responsibility to other actors like politicians (Synthia and Kabir, 2015). In interviews on plastic bag pollution, Malian women emphasized structural problems (e.g., the lack of appropriate waste collection services) and called for political solutions (Braun and Traore, 2015). Intriguingly, when policy makers were interviewed, they emphasized the consumers' responsibility (Braun and Traore, 2015).

4.2.1.7. Social factors. Several studies suggested that social pressure is an important variable influencing the use of plastic (Arı and Yılmaz, 2017; Carrigan et al., 2011; Musa et al., 2013). Furthermore, social desirability seems to be relevant for reporting plastic avoidance behavior (Sharp et al., 2010; Yeow et al., 2014).

Initial evidence showed that guilt affects plastic avoidance (Muralidharan and Sheehan, 2017). For example, people reported both feelings of guilt and the fear of being judged or criticized by other customers, when taking plastic bags at a counter (Cherrier, 2006).

Avoidance of plastic is further utilized as a symbolic action conveying a certain social identity, as suggested by Australian consumers reporting to use reusable bags to be visibly identified as part of an environmentally friendly group (Cherrier, 2006). Similarly, avoiding plastic might be a deliberate act to firm one's cultural identity, as it was reported by women in Mali (Braun and Traore, 2015). This effect was influenced by age, as older women were more concerned about preserving their cultural heritage by avoiding plastic bags, while younger women felt rather proud of being "modern" by using plastic bags (Braun and Traore, 2015). Relatedly, fans of a certain shoe brand that promotes its plastic shoes as especially flexible and robust due to its material, form their own identity including their own name (Ferreira and Scaraboto, 2016). Similar to the emotionality of these fans of the plastic shoes, another study indicated that emotions play a larger role than rational

evaluations for purchasing a product in an environmental-friendly package (Koenig-Lewis et al., 2014; see also Phillips, 2016, for qualitative data on affective responses towards plastic use).

Since social desirability and identity are relevant for plastic use and avoidance, it is likely that related norms are important too. When analyzing the case of a town in England where a plastic bag ban had been enforced by local traders, Carrigan et al. (2011) reported a shift in community norms for plastic bags throughout the process of becoming plastic bag free. Additionally, ethical evaluations had a direct (Chan et al., 2008) or indirect influence on the intention to bring one's own bag (Chang and Chou, 2018).

Clapp and Swanston (2009) pointed out that anti-plastic norms first occurred in Southern countries, driven by simultaneous, non-networked bottom-up initiatives. Notably, changes in anti-plastic-norms usually go hand in hand with structural changes. Therefore, it is often difficult to attribute behavioral changes to changed norms or to facilitating external conditions as was shown in the study on immigrants by Romero et al. (2018; see above).

4.2.2. Factors influencing plastic waste handling

Dealing with plastic does not only include the consumption or avoidance of plastic products but also handling its waste, which includes recycling, littering, and reusing. The behavior shown depends strongly on the respective country and its cultures and infrastructure. For example, open dumping or burning is reported to be common in African countries or China (e.g., Madigele et al., 2017; Otsyina et al., 2018), whereas studies from Europe usually rate plastic as one of the most commonly recycled materials (e.g., Jones et al., 2016). In an Indian study, households with lower income reused waste themselves, while households with higher income gave it away for reuse and recycling, suggesting that socioeconomic differences within a country might play a role as well (Pandey et al., 2017). There are further studies on creative waste disposal (e.g., the production of art from of recycled plastics; McKay and Perez, 2018), which are not reported here due to their individual case character. As the majority of studies addressed recycling or littering, we will focus on these.

4.2.2.1. Recycling. Several studies focused on predicting recycling behavior or its intention using the theory of planned behavior. By doing so, between 29% (Knussen et al., 2004) and 44% (Chan, 1998) of the variance of recycling intention could be explained. Contrary to the findings mentioned above on the avoidance of plastic, social norms had no (Knussen et al., 2004; Pakpour et al., 2014; Tonglet et al., 2004a; Tonglet et al., 2004b) or only weak (Chan, 1998; Tih and Zainol, 2012) influence on recycling intention and behavior. Examining norms further, one study found that descriptive (i.e., perception of how others actually behave) but not injunctive (i.e., perception of how others expect somebody to behave) norms predicted the intention to engage in household recycling (White et al., 2009).

Constructs having an influence exceeding the constructs of the theory of planned behavior were past behavior (Knussen et al., 2004; Pakpour et al., 2014; Tonglet et al., 2004a), habits (Klöckner and Oppedal, 2011; Knussen et al., 2004; Ofstad et al., 2017), action planning (Pakpour et al., 2014), moral norms, and self-identity (Pakpour et al., 2014; White et al., 2009), as well as green practice consequences (i.e., knowledge of the outcomes associated with one's green practices; Tih and Zainol, 2012).

Tonglet et al., (2004a) reported that recycling attitudes are the main determinant of recycling behavior, and that opportunities, knowledge, and not feeling deterred by behavior costs are antecedents of pro-recycling attitudes. Similarly, convenience or cost of recycling (e.g., the necessity of cleaning packaging before recycling; Ahmad et al., 2016; Klaiman et al., 2016), and context factors, such as the availability of waste bins (Madigele et al., 2017) or waste bins being overloaded (Vogt and Nunes, 2014), were considered important. Mass communication was identified as an antecedent of subjective norms (Chan, 1998). Unlike individual personal decisions, where environmental reasons seemed more relevant than financial incentives (Afroz et al., 2017), financial considerations played a crucial role in company decisions (Meng et al., 2015).

4.2.2.2. Littering. Sociodemographic variables predicting littering are gender, income, and education. Men took stronger action against littering (Rayon-Viña et al., 2018) though findings are inconsistent as in another study where women reported more concern about litter and had greater personal motivation and competence to reduce it (Hartley et al., 2018b). Littering amount per day at beaches was higher in a region frequented by people with lower income and literacy degree (Santos et al., 2005).

People from less littered regions showed more engagement in waste reduction strategies (Kiessling et al., 2017), although elsewhere concern and willingness to act were higher the more litter people noticed (Hartley et al., 2018b). Another study found no correlation between the perception of and action against littering (Rayon-Viña et al., 2018).

Social norms were found to be an important predictor for the act of littering, and awareness of the anti-social nature of littering was strongly related (Shimazu, 2018). Interestingly, environmental awareness was less predictive for reported littering behavior (Shimazu, 2018). Tourists were found to be primarily responsible for littering – again implying the relevance of social norms as tourists might have different norms than locals (Santos et al., 2005). However, this finding may also be explained by the fact that tourists feel less responsible for their travel destination than locals as they stay for shorter time and take less consequences, or because being on holiday may activate certain behavior patterns.

In summary, dealing with plastic is highly influenced by social factors (e.g., social desirability and norms), context factors, convenience, and habits. As far as the handling of plastic waste is concerned, there are mainly studies on recycling and littering. Recycling behavior can be well predicted by the constructs of the theory of planned behavior, with social norms being least important. In turn, social factors are particularly significant for littering. The studies reviewed imply to consider cultural differences when studying plastic-related behavior. These differences can arise because distinct external conditions prevail in different countries, but they may also be explained by varying norms, among others.

4.3. Solutions to tackle the plastic problem

In view of the huge challenges elicited by plastic consumption, solutions to tackle the plastic problem are needed. First, we introduce a variety of regulatory and economic policy instruments aimed at reducing plastic use which either already exist or are considered for implementation in countries around the world. Second, we will review “softer” and more psychological intervention strategies which are currently tested.

4.3.1. Regulatory and economic policy instruments to reduce plastic use

There are two main types of policy instruments aimed at reducing plastic use. While some countries have imposed full or partial bans on plastic bags or other plastic items, other countries prefer economic policy instruments such as fees, levies, or taxes that are paid either by the retail industry or the consumers (Ritch et al., 2009; Saidan et al., 2017a; Syberg et al., 2018; Wagner, 2017). The implementation of these instruments varies between and within countries with respect to policy details (e.g., the size and thickness of plastic bags). Here, we provide a brief overview of the two types of policy instruments and discuss some related psychological and political aspects. It is still unclear which instruments are most environmentally effective and politically acceptable (Ritch et al., 2009). In addition, note that another policy strategy, namely the so-called ‘Extended Producer Responsibility’, aims to return the responsibility for products after their use back to the producers, for example by taking back, reusing, or recycling products (optionally by a third party; see Hanisch, 2000; McKerlie et al.,

2006). However, as we focus on consumers in this review it is not elaborated here.

4.3.1.1. Bans. Bans of some kind are a widely adopted policy action and they are, by their nature, an effective way to reduce plastic use. Nevertheless, it is important to consider some potential unintended consequences, such as the use of alternative bags (e.g., of paper). The latter may be as harmful for the environment as plastic bags, but may be judged by consumers as more environmentally friendly (Synthia and Kabir, 2015; and see above in Section 4.1.2.1). This effect can be countervailed by also imposing fees or taxes on alternative bags, which was done successfully in many US local governments (Wagner, 2017). Another problem associated with bans is that they may evoke strong consumer resistance. This, in turn, may reduce the political acceptability of this policy instrument. However, research from Australia indicates that those consumers who strongly relied on plastic bags before a ban became supportive of the policy after its introduction, which may be due to visibility of their positive environmental effects (Sharp et al., 2010). A study from Brazil also showed high approval ratings after the ban was introduced, with over 86% of the participants considering the new law important or very important (Santos et al., 2013).

4.3.1.2. Plastic charges and other types of economic incentives. The seemingly most widespread policy instrument to reduce plastic use is the introduction of a charge (alternatively referred to as "tax" or "fee", depending on context). Several studies have examined the effectiveness of a charge in changing behavior as well as its acceptance by customers and industry. With respect to effectiveness, studies from various high- and low-income countries indicated that disposable plastic bag use dropped by 40% to 90% after implementing a charge (e.g., Convery et al., 2007; Dikgang et al., 2012; Dikgang and Visser, 2012; He, 2012; Poortinga et al., 2013; Thomas et al., 2016). For example, Wales introduced a 0.07€ charge for "single-use carrier bags" in 2011. The distribution of such bags fell by over 80%, while the number of people "always" bringing their own shopping bag increased by over 20% (Poortinga et al., 2013; Thomas et al., 2016). Noteworthy, such changes were not observed in other UK countries where no charge was introduced during that time. Moreover, the results from Thomas et al. (2016) suggest that the plastic charge had additional environmental effects, namely insofar as the use of one's own bag seemed to have increased the adoption of other, unrelated types of pro-environmental behaviors and attitudes (see also Truelove et al., 2014, for a theoretical review on spillover research).

Some authors, however, suggested that the impact of a plastic charge might be overestimated, because unobserved factors such as changes in social norms are often not accounted for when comparing simple differences before and after the implementation of a charge (Rivers et al., 2017). In other words, it may not just be the monetary incentive that drives the behavioral changes, but also anti-plastic norms which inspire the introduction of the policy, but arguably may also be a consequence of it. This relates to research investigating the underlying motives of behavioral change resulting from a plastic charge. For example, a study from Portugal showed that for most of the participants indeed the main reason for not using plastic bags was to avoid the payment, but other reasons associated with convenience and environmental concern were mentioned as well (Martinho et al., 2017). Another issue related to the policy effectiveness is the long-term dynamics. That is, in some countries such as South Africa it was observed that demand for plastic bags went down as a consequence of introducing a charge, but after approximately a year increased again, though never completely to initial levels (Dikgang et al., 2012; Dikgang and Visser, 2012; Hasson et al., 2007). While this particular case can partially be explained by the fact that the initial charge levels were decreased, these observations certainly suggest the need for more long-term research to assess the instrument effects.

Finally, plastic charges are relatively accepted by consumers as well as the retail industry. For example, the Irish plastic bag levy is very well perceived by retailers because of financial savings, whereas almost all consumers perceived positive environmental benefits and no negative effects in terms of convenience (Convery et al., 2007; see also Zen et al., 2013). Nevertheless, research from Argentina indicates somewhat lower levels of acceptance by consumers, which may be due to differences in environmental concern or in terms of how the government has implemented and communicated the policy (Jakovcevic et al., 2014).

Another type of economic incentive is provided by deposit-refund systems, which compensate consumers monetarily for returning plastic products. For example, research from the US and Australia shows that coastal debris is approximately 40% lower in states that have such a refund system compared to others without it (Schuyler et al., 2018). Relatedly, we present additional findings on recycling schemes below in Section 4.3.2.1.

To conclude, regulatory and economic public policies are effective in reducing plastic use. While bans are evidently most effective, they may not be politically feasible in every context. Plastic charges are a promising alternative, though more research is needed to investigate their long-term effects.

4.3.2. Psychological interventions

Beyond regulatory and economic interventions less coercive ones, such as educational approaches or improvement of infrastructure, are aimed at increasing awareness and to encourage behavior change. Guided by the three R's of waste management (recycle, reuse, and reduce; Thompson et al., 2009a), we now provide an overview of psychological interventions that aim at tackling the plastic problem.

4.3.2.1. Recycle. In the 1980's, many studies examined recycling and littering behavior as well as the influence of personal and situational factors on them (for reviews, see Schultz et al., 1995; Huffman et al., 1995). Later meta-analyses have focused on recycling in different settings such as at the workplace (Oke, 2015) or at home (Varotto and Spagnolli, 2017). However, most studies did not explicitly focus on plastic. Yet, a generalization over materials might be problematic when predicting recycling behavior (Schultz et al., 1995). In the following, only studies that investigated plastic explicitly are reviewed.

4.3.2.1.1. Accessibility of recycling schemes. Most of the studies investigated interventions at the point of action. The implementation of recycling stations in university settings encouraged recycling behavior (McCoy et al., 2018; O'Connor et al., 2010; Ofstad et al., 2017). While lower distances to recycling bins enhanced recycling, a mere increase of bin quantity did not (O'Connor et al., 2010). Recycling amount of household plastic waste was higher when people had to bring it to public places, compared to when it was collected at the sidewalk, although more people participated in the latter (McDonald and Ball, 1998). In other studies, the recycling rate for household collection was higher than for "bring" schemes (Struk, 2017; Viscusi et al., 2012). Additionally, incentives increased the overall recycling rate of plastic (Struk, 2017). Similarly, deposit systems for plastic bottles increased the attractiveness of "bring" schemes (Viscusi et al., 2012). Although, higher density of drop-off sites for "bring" schemes had only small effects (Struk, 2017), recycling rates decreased markedly when they were more than five miles away (Viscusi et al., 2012). In a Japanese study, people had a higher willingness to pay for less packaged shampoo when a unit-based pricing system of waste collection existed in their municipality. However, the general willingness to pay was quite low. When unit-based pricing was combined with plastic separation, willingness to pay decreased suggesting that recycling can lessen plastic reduction behavior (Yamaguchi and Takeuchi, 2016).

4.3.2.1.2. Appearance of recycling stations. People in Greece associate certain colors of public bins with different waste materials; while yellow was preferred for used plastic water bottles in particular, orange, yellow, or purple was chosen for plastic or packaging in general (Keramitsoglou and Tsagarakis, 2018). However, only changing the color of the bin had no effects on recycling rate as a US study indicated (O'Connor et al., 2010). Moreover, covered bins with special drop slots and lids were preferred (Keramitsoglou and Tsagarakis, 2018). Other studies showed that signs prompting recycling increased correct recycling even when proximity to the bin decreased, and hence highlight the role of messages on the bins, especially in combination with the implementation of recycling schemes (Fritz et al., 2017; Miller et al., 2016). Furthermore, positive messages such as "thank you" or those referring to the environment encouraged people to continue recycling (Keramitsoglou and Tsagarakis, 2018).

4.3.2.1.3. Informational campaigns. Recycling behavior was strengthened when information campaigns were added to the implementation of recycling schemes (Cheung et al., 2018; Ofstad et al., 2017; Pearson et al., 2014). Information campaigns using posters, TV screens, flyers, websites, or broader environmental campaigns increased awareness, knowledge, and self-reported disposal behavior (Cheung et al., 2018; Ofstad et al., 2017; Pearson et al., 2014). In contrast, informational treatments using text or video did not increase recycling behavior but rather changed using preferences from plastic packaging to paper and boxboard (Klaiman et al., 2016). Nevertheless, a lack of instructions might be a barrier to recycle plastic (Vogt and Nunes, 2014). While pushy requests (e.g., "You must recycle plastic container") were persuasive for recipients who already valued recycling as important, suggestive appeals (e.g., "It's worth recycling plastic containers") were more effective to initiate recycling intention for those who find recycling less important (Kronrod et al., 2012). When participants were asked to plan and visualize when, where, and how to recycle their used plastic cups and old paper, this type of implementation intention increased recycling rates and thus decreased the number of cups in the dustbins by roughly 75% (Holland et al., 2006). An awareness campaign including knowledge transfer and vocational training was also proposed to increase recycling in refugee camps in Jordan (Saidan et al., 2017b).

4.3.2.1.4. Rebound effects. In an online experiment participants were asked to do their typical grocery shopping in an online supermarket. After shopping they got fictitious feedback independent of their real shopping behavior. When people were told that they were considered as "green shoppers" (in comparison to a bogus peer group), participants recycled less of disposed material they got for a creativity task before (Longoni et al., 2014). The decreased motivation to gain a green identity in this group indicates a self-licensing effect, signifying people who feel save in their goal achievement (e.g., being a green consumer) makes people to worry less about other unsustainable behavior (Longoni et al., 2014). Similarly, US students were experimentally triggered to either recycle a water bottle, to throw it in the trash, or neither. Those who identified as Democrats and recycled their bottle were less willing to support a green fund compared to the control condition (Truelove et al., 2016). This effect was mediated by environmental identity, indicating that for Democrats (who already show a high recycling baseline) recycling might be too easy to increase environmental identity. Thus, promoting recycling in certain groups could lead to a decrease in pro-environmental behavior in general (Truelove et al., 2016).

4.3.2.1.5. Conclusion. Implementing recycling schemes are necessary to increase recycling. However, it needs to be well planned, especially with a view on local conditions (i.e., proximity of bins, combination with incentives and information) and rebound effects of recycling policy. An elaborate but powerful approach is implementation intention to tackle habit change for a concrete behavior.

4.3.2.2. Reuse. One main characteristic of plastic is its durability. In a somewhat paradoxical contrast, it is mostly used in a disposable manner. Increasing the reuse of plastic products might therefore provide a solution to the wastage of this durable material. For example, in interviews, respondents stated to use plastic bottles "for a purpose other than that for which it was initially designed" (Caner and Pascall, 2010, p. 418) when a screw-type closure is used and bottles could be easily cleaned and refilled. However, only a few studies, which we review in this section, evaluated interventions related to reuse in order to avoid plastic waste. Most of them focus on beverage containers or plastic bags.

4.3.2.2.1. Provision of alternatives. US students who received a reusable water bottle and plastic cutlery for their matriculation used less disposable bottles and supported the bottle ban at the university (Santos and Van Der Linden, 2016). Similarly, information about the reduction of plastic bottles before implementing a water refill system helped to increase the willingness to pay, environmental awareness, and responsibility attribution in Japanese students (Uehara and Ynacay-Nye, 2018). In the UK, different interventions on reusable coffee cups were evaluated and the study authors concluded that providing a reusable cup increased its use, even in the long run (Poortinga and Whitaker, 2018). Furthermore, a charge on disposable cups – but not a discount – increased the use of the reusable cup. The single intervention had only small effects but they increased when combining interventions, in particular when message framing is added (Poortinga and Whitaker, 2018).

4.3.2.2.2. Rewards and framing. The interventions using a ban or taxes leading to the reuse of plastic bags were already mentioned above. Another program successfully encouraged consumers – even in the long run – to use reusable instead of plastic bags via monetary rewards and peer pressure (Jiang, 2016). Advertisements in a US supermarket encouraging consumers to bring reusable bags were either formulated as a gain "Bring reusable bags and avoid a fee" or as a loss "Bring reusable bags or pay the tax". While both ads worked, the first was less effective for people with low self-transcendence values (i.e., higher egoistic needs and low environmental awareness; Muralidharan and Sheehan, 2016, 2017). Vones et al. (2018) presented another option to build awareness for the reuse of plastic (without evaluating the project) by doing a beach-clean-up with a subsequent 3-D-printing workshop reusing the collected waste.

4.3.2.2.3. Conclusion. Providing alternatives such as reusable coffee cups or refillable bottles are promising approaches to reduce plastic waste. However, they are quite expensive and thus charges or bans may be more attractive for stakeholders. Moreover, alternatives have only selective effects with regard to a concrete product questioning the broader scope. Regulations of prices yielded to more reuse – not only due to the money benefit but also because of a subsequent shift in norms. Similar to recycling, a combination of available options and information campaigns seem to be promising.

4.3.2.3. Reduce. While both recycling and reuse practices lower the plastic waste in the environment, they cannot alleviate resource use in general. Thus, reducing plastic use and production are critical. Both consumers and salespersons play essential roles for demand and supply. Recently, so called "zero waste" grocery stores emerged, and both advantages and disadvantages thereof are discussed in the literature (Beitzen-Heineke et al., 2017). However, most of the studies focusing on plastic reduction behavior refer to education on marine litter and address children, educators, and public.

4.3.2.3.1. Educating school children. School education programs increased both knowledge about causes and impacts of marine litter and environmental behavior intention in children (Hartley et al., 2015; Owens, 2018; So et al., 2016; Veiga et al., 2016). Active learning elements such as gaming simulations with role plays in a simulated city (Yeung et al., 2017), inquiry learning strategies including independent learning with experiments (Hartley et al., 2015; Yeung et al., 2017), collecting of marine debris and report writing for a state legislator (Owens, 2018), and video contests about marine litter in different

European countries (Hartley et al., 2018a; Veiga et al., 2016) were used to change knowledge and behavior. Gaming simulation further induced attitude change via cognitive dissonance (i.e., psychological discomfort due to inconsistency between one's beliefs and behaviors; Yeung et al., 2017). Inquiry learning strategies focusing on the classification of plastics failed to increase waste-related behavior (i.e., reduce, reuse, and recycle) but led to an increase in knowledge about plastic types (So et al., 2016). Inquiry learning strategies including experiments, artworks, and demonstrations on marine litter revealed some overarching effects, as school children's self-reported behavior on littering and buying plastic packaging was reduced while the motivation to encourage others to do so increased (Hartley et al., 2015).

4.3.2.3.2. Training of stakeholders. Some programs did not address school children directly but aimed at teaching educators. After working with an online tool that included learning about marine litter and pedagogical skills, knowledge and perceived skills of educators increased and they expressed high intentions to integrate marine litter education in future classes (Hartley et al., 2018a; see Cheung et al., 2018, for a similar study). Moreover, art presentation in an educational context was discussed to initiate useful conversations with children about mass consumption and pollution (O'Gorman, 2017).

4.3.2.3.3. Educating the public. To raise awareness for plastic pollution, several countries have implemented campaigns. For example, activities developed by the MARLISCO initiative (e.g., public exhibitions, stakeholder meetings, and education tools) increased the feeling of being part of the solution as well as societal awareness and engagement related to marine litter (Veiga et al., 2016). An online campaign for adolescents that included tailored information (e.g., small action steps) increased knowledge, attitude, or behavior intention depending on the respective participants' stage of change (Chib et al., 2009). When different councils in Australia were compared, those with educational campaigns on why and how to dispose waste correctly had less waste on their coastlines (Willis et al., 2018). Furthermore, Greek informational campaigns aimed to reduce plastic bags raised the willingness to pay for protection of coastal environments but had no effect on the willingness to take action (Latinopoulos et al., 2018).

4.3.2.3.4. Participation in plastic-reduction activities. Citizen science projects in which people are asked to participate in beach clean-ups increased the awareness of marine littering (Syberg et al., 2018; Yeo et al., 2015). Knowledge and positive attitudes were underlying factors for the willingness to participate in "plastic-free"-campaigns in Malaysia (Afroz et al., 2017). When fishermen encouraged others not to litter and participated also in beach clean-ups they developed a sense of ownership for "their" beaches along with a feeling of responsibility (Brennan and Portman, 2017). Involving school students in plastic-free practices, in which they helped to organize activities as co-researchers, led to an improvement in their awareness and behavior of littering (Mapotse and Mashiloane, 2017).

4.3.2.3.5. Interventions at the point of consumption. Looking at the product presentation, a non-overpacked product tagged with "No excess packaging" increased the purchase of these products. When this tagged product was additionally combined with a premium brand the purchase rate was highest (Elgaaïed-Gambier, 2016). A voice prompt by the salesperson during the purchase situation (i.e., customers were asked whether they wanted a free plastic bag instead of automatically handing them one) lead to a 5% decrease in plastic bag consumption (Ohtomo and Ohnuma, 2014). To motivate shop owners in Indonesia to sell reusable instead of plastic bags, information activating authority endorsements (i.e., head of the village supports the idea of distributing reusable bags) was more effective than information activating social norms or monetary incentives (Spranz et al., 2018). Such social influence of role models is also important for recipients indicated by the finding that the intention to reduce plastic waste was increased when recipients have read a media report with an actor behaving ecologically, whereas the actor's social proximity was relevant when recipients had low environmental consciousness (Arlt et al., 2012). Furthermore, making one's intention public helps to reduce plastic consumption via social pressure. Participants who signed a commitment to refuse free plastic bags were more likely to reduce their use afterward (Rubens et al., 2015). Reese and Junge (2017) used a game in which people could mark a plastic consumption pattern on a card after its realization (e.g., using a bag for purchase or making a purchase without plastic packaging) and then give it to another person of choice. When the task was perceived as moderately difficult, participants' collective efficacy (i.e., their feeling that acting together helps reach a goal) was highest and most predictive for behavioral intentions.

4.3.2.3.6. Conclusion. Participation in clean-up activities and educational approaches was effective to raise awareness and partly also to change behavior intention. Focusing on school children and their educators is promising to create awareness for environmental challenges at an early age. Overall, inquiry learning strategies and gaming approaches encouraging people to get active themselves seem most promising. The role of social norms became apparent as far as the concrete purchase situation is concerned. Making one's purpose public via commitment or introducing role models were successful approaches to reduce plastic consumption. Nevertheless, more research is needed to identify factors for a general transformation in purchase or reduction behavior.

5. Discussion

5.1. Summary

The current review gave a comprehensive overview of the available social-scientific literature addressing plastic with a focus on risk awareness, consumer preferences, plastic use and disposal behavior, and behavior-oriented intervention strategies. By reviewing 187 articles from all over the world, this review provides a summary of the existing knowledge for researchers and stakeholders worldwide. Further, it identifies promising behavior-based solutions for the plastic problem.

The literature search revealed that interest in the plastic problem has markedly increased in social science in the last few years (Fig. 2). These studies were from different countries worldwide. Although large-scaled surveys were relatively rare and focused mostly on countries in Europe or the US (Gelcich et al., 2014; Hartley et al., 2018b; Herbes et al., 2018), single studies were from all over the world and lead to a relatively weak bias for industrialized nations compared to other areas of research in which this bias is stronger. As plastic pollution is most often perceived as a threat for marine ecosystems (see Lotze et al., 2018, for a worldwide comparison), our review also indicates that most studies originate from countries with a coastline (Fig. 1). The visibility of the problem in marine areas might have led to a stronger interest in this field. In total, across the 187 studies reviewed samples from 57 countries were investigated (Fig. 1). Similarly, the first authors of the reviewed studies had an affiliation in 49 different countries (see S1 for an overview of all reviewed studies, the location of data collection, and the country where the first author was based at the time of publication). Although this diversity of study samples is important and much appreciated, drawing general conclusions is – so far – difficult due to the yet limited number of studies per country and their associated culture(s), laws, infrastructure, and further situational factors.

Overall, the studies reviewed were from different (sub-)disciplines, including marketing, consumer studies, psychology, educational science, and environmental science, presenting a diversity of perspectives on the present topic. The articles covered various methodological approaches making comparisons and general conclusions difficult. Many studies, especially those focusing on awareness, perception, and attitudes, were of a qualitative nature. Moreover, most studies on behavior either focused on intention or self-reported behavior rather than actual behavior – although there are well-known gaps between attitudes, intentions, and behavior (see Kollmuss and Agyeman, 2002).

The studies identified high problem awareness of plastic pollution. In addition, people perceive certain health hazards related to plastic

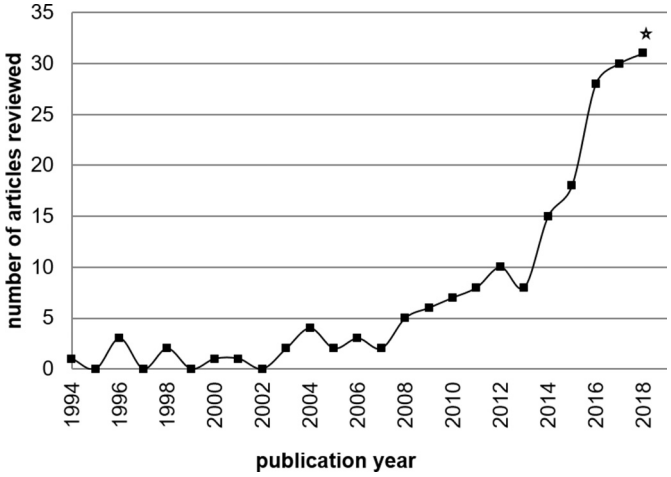

Fig. 2. Number of articles reviewed by year of publication. * Note that only articles published before September 27, 2018 were considered in this review.

consumption. Although plastic is perceived as rather environmentally unfriendly, it is frequently used and appreciated for its practical functions and availability. Thus, plastic consumption is generally high, but this also seems to vary between contexts and cultures. Similarly, this might be the case for reusing plastic as, for example, people with lower income tend to reuse plastic more often (Pandey et al., 2017). The reviewed studies showed that knowledge about alternatives to plastics and their characteristics is relatively low. Behaviors related to the use of plastic seem to be most affected by habits and (social) norms. Both political (e.g., bans, charges) and psychological (e.g., inquiry learning strategies, implementation intention) intervention strategies aim to change these by focusing on habits, availability, costs, situational factors, and awareness.

5.2. Implications for behavior-based solutions

Although problem awareness is high, behavior change does not follow automatically, mainly because of the following obstacles: 1) perceived practicability and convenience in the consumption context, 2) lack of knowledge on how to implement alternatives or lack of opportunities, 3) strong habits, and 4) shift of responsibility. Therefore, behavior-based solutions need to approach these issues. This may be done in an interdisciplinary manner. For example, by designing (by engineers), evaluating (by material, environmental, and social scientists) and promoting (by media) alternative materials that do have the appreciated properties of plastic but are more environmentally friendly (e.g., see Haider et al., 2018, for a good example considering some of these aspects). Consumers have not only insufficient knowledge about alternative materials but also about what an environmentally friendly material is, as indicated by the divergence of consumer perception and life cycle analyses (see Section 4.1.2.1). Since consumers focus mainly on post-consumption (e.g., recyclability), more information about environmental impacts in the whole life cycle of a product may increase the knowledge about environmentally friendly materials and guide the consumer to better alternatives. However, since awareness and knowledge are not the only relevant factors influencing behavior, an increase in these does not necessarily imply a change in behavior. Despite the attitudes of the consumers, situational factors such as an appropriate infrastructure for alternatives need to be considered. Moreover, social and personal factors as well as habits play a crucial role, as suggested by the studies on plastic-related behavior. To initiate a habit change, 'windows of opportunity' (Schäfer et al., 2012) – periods where people are open for new behaviors as external conditions change (e.g., relocation) – may be preferably used. As windows of opportunity are not always available, a change in situational factors such as the provision of alternatives should also be used to initiate new behavior. Individuals that start a new behavior, might lead others to follow, can hence change norms, and set a spiral of action in motion. Thus, reaching a critical mass of acting people is helpful.

For all behavior-based solutions, it is important to consider structural, situational, and cultural factors. Although, the available literature is insufficient to make a final conclusion, awareness of the situation in a specific region (e.g., whether there is infrastructure for recycling) and what problems are most pressing (e.g., health hazards and thus importance of hygienic packaging) helps to identify the change of behavior that is most promising (cf., Steg and Vlek, 2009). Moreover, depending on particular circumstances and/or cultural background, demands of situational factors and infrastructure need to be considered (e.g., waste management in refugee camps vs. residential complexes; cf., O'Connor et al., 2010; Saidan et al., 2017b).

The reviewed literature shows that plastic consumption and avoidance is generally similar to other environmental behaviors as 1) it affects several aspects in life (as does mobility, for instance), 2) there is a conflict between problem awareness and behavior, and 3) it is predicted by situational factors as well as personal factors such as sociodemographics, habits, control beliefs, moral, and social norms. Therefore, models explaining pro-environmental behavior, such as the so-called SIMPEA which addresses social identity processes that affect appraisal and response to collective environmental challenges (Fritsche et al., 2017), might be helpful to further understand and study plastic-related behavior. Additionally, knowledge from available behavior-based solutions on other environmental behaviors can be used to create interventions – and vice versa. For example, the success of plastic bag bans, fees, and taxes may motivate bans of other environment-damaging products. However, so far, the field lacks studies evaluating the long-term effects of such political interventions. What makes plastic-related behavior special is its diversity (consumption of alternatives, avoidance, reuse, recycling). Thus, a close look at specific behavioral antecedents as well as examining the impact of political measures as bans or change in infrastructure becomes therefore necessary in intervention context.

Citizen science and organized clean-ups appear to be promising approaches to raise awareness and responsibility, motivate reuse, and change behavior since, for example, people residing near clean beaches engage more in waste-reduction approaches (Kiessling et al., 2017). Further, organized clean-ups might be successful due to two other factors: creating a new habit by doing it once with instructions and strengthening the social norm by doing it with others. Since humans are social beings, social norms play a major role in (environmental) behavior. As it was pointed out throughout the review, norms predict different forms of plastic-related behavior although they were not as strong as in classical studies using the theory of planned behavior. Moreover, successful intervention studies with role models and voice prompts by salespersons highlight the social factor. Therefore, interventions that change norms are promising. When combined with adjusted situational factors and information they might have even bigger effects. Overall, intervention strategies should be combined since, so far, no strategy alone is sufficient to reduce the immense use of plastic. Moreover, the interventions need to be well-planned to reduce unwanted effects (e.g., licensing effects, perceived green-washing, or rebound-effects) and to meet the needs of the target group and therefore gain their acceptance.

Furthermore, different actors are needed to approach the plastic problem from various directions. While educators, media directors, and organizers of activities, such as beach clean-ups, are in positions to raise awareness, increase knowledge, and train alternative behavior patterns, stakeholders, politicians, and salespersons are capable to adjust general circumstances and situational factors to change consumption and waste behavior. For example, promoting a 'circular economy' or implementing an 'Extended Producer Responsibility' might be fruitful to make producers accountable and thus should be pursued by politics and public. Despite recently introduced laws on the national level that

contribute to tackling the plastic problem (e.g., prohibition of plastic microbeads in cosmetics, U.S. Government Publishing Office, 2015), present developments (e.g., China's recent decision to stop accepting plastic from other countries) underline the pressing need for global, integrated solutions.

5.3. Implications for future research

The current review and conclusions have some limitations which, on the one hand, are due to the nature of plastic and behavior related to it, and on the other hand due to characteristics of the available literature. Plastic-related behavior is diverse and thus difficult to delineate. Although we reviewed a large amount of studies, only few focused on a particular behavior (e.g., avoiding plastic) and thus conclusions on these are limited. In contrast, recycling behavior is very well studied but plastic was explicitly considered only sparsely. This diversity, non-specificity, and the limited amount of studies might lead to different predictors of behavior and a low comparability of findings. Therefore, future studies should further investigate plastic-specific behavior and focus on real instead of reported or intended behavior. Furthermore, methods measuring (plastic) avoidance behavior should be developed. Moreover, research should endeavor to study breaking habits, since this is needed to change plastic-related behavior in the long-term.

In general, most studies investigating perception and consumption focused on plastic as packaging material or bags, while littering and recycling studies often did not classify waste origin or type. Interestingly, we found only a few studies investigating attitudes or behaviors related to microplastics, although this issue is hotly debated in both science and media. So far, the social-scientific literature largely ignored plastic types other than packaging or bags. We therefore recommend that future studies focus also on microplastics and other origins of plastic waste (e.g., from fishing utensils, electronic devices, or agriculture).

Noteworthy, some studies were interdisciplinary, combining for example psychology and environmental science. However, the field lacks studies in the areas of media and communication science although plastic became more and more abundant in the media and thus scientific work on the effects of such media presence is much needed. Since plastic-related perception and behavior and the research of these is so diverse, this review is rather descriptive, and may not sufficiently cover the entire literature relevant. Furthermore, the quality of the studies reviewed varied strongly and was generally rather low compared to the standard of current psychological research. Therefore and because of the limitations above, conclusions should be taken with caution and future studies are needed to confirm the findings.

5.4. Conclusion

The plastic problem is a major challenge of our times and needs interdisciplinary and global solutions. This review provides a first overview of the social-scientific literature and can serve as a basis for both researchers and stakeholders to develop further investigations and implement behavior-based solutions. The current work shows that the research field is growing, very diverse, originating from different countries and disciplines, and using a wide range of methods. Because of the limitations mentioned above, general conclusions are difficult. Nevertheless, the reviewed literature suggests that, although problem awareness is high, the perceived advantages of plastic, consumer habits, and situational factors make it difficult for people to act accordingly. Bans and increased costs of plastic products as well as a combination of psychological interventions seem to be promising measures to reduce plastic consumption and waste. All actors from science, policy, industry, trade, and the general public have to work together to avoid a shift of responsibility. More research is needed to improve current interventions and to create additional powerful, immediate, and global solutions to limit the amount of plastic waste in the environment.

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