# RISK PERCEPTION: THE CASE OF MICROPLASTICS

## A DISCUSSION OF ENVIRONMENTAL RISK PERCEPTION FOCUSED ON THE MICROPLASTIC ISSUE

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## 1. Introduction

Risk can be generally understood as the possibility that situations or events might lead to consequences that affect aspects of what humans value (Renn and Rohrmann, 2000). Risk perception involves implicit or explicit judgements of the likelihood or uncertainty as well as the desirability or undesirability of uncertain effects, which yield some benefit or cost (Eiser, 2004).[1] The formal definition of risk often entails the magnitude and probability of harmful consequences (Aven and Renn, 2009), and risk perceptions include these dimensions, along with perceptions of familiarity and controllability, dread and catastrophic potential, as well as affective and emotional responses (Finucane et al., 2000; Slovic, 2000; 2016). Risk perceptions deviate from numerical risk estimates because they are not exclusively determined by statistics and probabilities, but also by qualitative factors related to the risks themselves and those perceiving them (Kortenkamp and Moore, 2011).

Environmental risks diverge from other types of risk. First, they are often characterized by high uncertainty and complexity, leading to complicated causal relationships and numerous consequences (Steg and De Groot, 2018). Moreover, they tend to develop from the behaviors of many individuals; consequently, mitigation likewise requires the actions of many people. Lastly, their consequences are often temporally delayed and geographically distant. Those who contribute to the risk are not necessarily those who suffer its consequences, which raises ethical issues (Steg and De Groot, 2018).

The current chapter focuses on risk perception of the environmental problem of microplastics (MP). MP are tiny particles of plastic, smaller than 5 mm. MP are found at growing concentrations in the environment and have accumulated even in the most distant (van Sebille et al., 2015; Egger et al., 2020). The public and academia are increasingly concerned about the possible effects of this global challenge

[1] Slovic (1999) argued that “danger” is a reality, but “risk” is socially constructed.

(SAPEA, 2019). Accordingly, it is necessary to gain an understanding of people's perceptions and engage the public to tackle this problem effectively (Pahl & Wyles, 2017).

The determinants of MP risk judgments are numerous and interrelated. Socio-psychological factors have substantial influence on the evaluation of such environmental risks. Furthermore, people's risk perceptions about MP are important to consider when addressing the threat MP pose. This chapter discusses the different aspects that may affect environmental risk perceptions, focusing on the case of MP. It begins by highlighting the characteristics of the hazard itself (Section 2) and moves on to the individual characteristics (Section 3), with an emphasis on the role of heuristics (Section 4), emotions (Section 5) and finally mental models (Section 6).

## 2. Hazard characteristics

There are cases in which people are wary of hazards that experts agree do not cause much significant harm, like electronic radiation from mobile telephones, while in other cases, people are ready and willing to expose themselves to hazards that result in large numbers of fatalities each year, such as drinking alcohol  (Siegrist and Arvai, 2020). Such divergences can be at least partially explained by specific characteristics of the hazards themselves. The core variables in risk perception research are (perceived) magnitude of the risk and risk acceptance (Renn and Rohrmann, 2000). Nonetheless, in most studies, many more risk-related aspects are included, such as qualitative features of the hazard (e.g., familiarity with the risk or associated fear), benefits (e.g., attractiveness of the risky activity), personal relation to the hazard (e.g., whether one voluntarily exposes oneself to it, degree of worry about the risk, etc.), and acceptability facets (e.g., willingness to pay or desired level of restrictions) (Renn and Rohrmann, 2000).

The psychometric paradigm (Fischoff, et al., 1979) suggests that different types of hazards can be mapped onto four dimensions across two axes, labelled dread risk and unknown risk, respectively.[2] Dread risk refers to the level to which the risk is perceived as alarming or as having grave consequences; unknown risk describes the level to which the risk is experienced as unfamiliar, new, unobservable or having delayed effects (Steg and de Groot, 2018). Dread risk includes features such as uncontrollable, catastrophic, dreaded, involuntary, fatal, inequitable, global, and difficult to reduce, whereas unknown risk includes risks that are unobservable, not understood by science, new, and have delayed effects (Kortenkamp and Moore, 2011). Risks with effects that are perceived as far off in time or as occurring in a faraway place are also included within this dimension (Eyal et al., 2008)). Non-experts' risk perceptions have been shown to correlate with these main dimensions. Risks rated as more dreadful and more unknown are perceived as riskier and less acceptable (Kortenkamp and Moore, 2011). Other investigations have identified more dimensions that are relevant for environmental challenges, such as whether people have moral concerns related to the risk and whether people feel that issues of equity are related to the risk (e.g., Bostrom et al., 2020). Another important factor discussed in the context of risk acceptance is whether the source of the risk is natural versus human/technological, as people tend to rank natural hazards lowest in risk magnitude ratings. These hazards seem to be perceived and evaluated as more tolerable than those stemming from human activities or technologies, even though objective risk assessments might not differ much (Renn and Rohrmann, 2000).

The ubiquity of MP in aquatic ecosystems has provoked a broad public debate on the unsustainable use and environmental impact of plastics (Kramm and Völker, 2018). However, as stated above, there are cases where the public perception of a particular hazard does not match experts' understanding of its impacts. While the environmental impacts of MP are not at all clear from a scientific perspective at present, public awareness of overall plastic pollution is extensive (Völker et al., 2020). In fact, most EU citizens worry about the consequences of plastics for the environment (87%) and for their own health (74%) (European Commission, 2017). Meanwhile, there has been ongoing debate about the relevance of this issue compared to other environmental challenges (Backhaus and Wagner, 2020),

[2] For empirical evidence, see Slovic (1987) and Teigen et al. (1988).

with some scholars arguing that the levels of environmental toxicity detected so far are too low to be of significant concern (Triebskorn et al., 2019). Such disparity between experts and public opinion can potentially be problematic when it results in policies and decisions that are disproportionate or not supported by science (Rist et al., 2018).

The public indeed has reported being highly concerned that MP could have an impact on the sustainable development of ecosystems and also threaten food safety and public health (European Commission, 2020; German Federal institute for Risk Assessment, 2020; SAPEA, 2019). Such levels of perceived risk might be explained in part by known/dread factors from the psychometric paradigm. With respect to the dread risk dimension, plastic and MP pollution are likely to be considered dreadful hazards given that plastic pollution is a form of involuntary exposure for animals and plants in the environment and a problem at a global scale. With respect to the unknown risk dimension, MP are a quite new hazard (Pahl and Wyles, 2017) that is not well understood by science, since research on them is still in its infancy (Rist et al., 2018). This may lead people to perceive this hazard as less well understood by science. Nonetheless, 53% of respondents in Kramm et al. (2022) perceived the state of scientific knowledge on MP as rather high or very high, suggesting the contrary. Moreover, MP are not easily observable (Pahl and Wyles, 2017), which should also make people lean more towards the unknown end of the spectrum. Additionally, regarding the sources of MP, since hazards stemming from human activities are perceived as riskier and less tolerable (Renn and Rohrmann, 2000), the fact that MP are a human-caused hazard might contribute to the high levels of perceived risk that have been reported.

## 3. Perceiver characteristics

Perceivers of risk differ on a wide range of variables that might influence risk perceptions (Siegrist and Árvai, 2020). Many such variables have been studied extensively in order to explain and predict individual differences in risk perceptions. In the case of MP, only a few studies have been conducted to investigate public risk perceptions (Yoon et al., 2021). Perceived consequences as well as knowledge and awareness determined pro-environmental attitudes in a study by Soares et al. (2021) in Portugal; nonetheless, concern did not enhance pro-environmental behavior intention significantly in a study by Deng et al. (2020) in China. Risk perception was also a pivotal determinant of pro-environmental behavioral intention related to MP in Korea (Yoon et al., 2021). The relation between expectations and perception (Tsiotsou, 2006) has also been found to be key in consumer decisions about green MP-free products (Nam et al., 2017). On that note, the most relevant individual characteristics and their implications for risk perceptions of MP are highlighted in the sections below.

### 3.1 Socio-demographics

Gender appears frequently to be weakly associated with risk perceptions (Cullen et al., 2018; Rivers, Arvai and Slovic, 2010); in addition, small or non-significant effects have been found for age (Bearth et al., 2019) as well as income (Nardi et al., 2020) and education (Bearth et al., 2019; Nardi et al., 2020). However, some studies have yielded more information about the relationship between risk perceptions and demographic characteristics. For example, in studies by Finucane and colleagues (2000), white women perceived significantly higher levels of risk across different hazards compared to white males, while the same was not found for nonwhite women and men. This indicates that gender and/or racial identity per se might not drive risk perceptions to the same extent as other psychological or cultural features (Rivers et al., 2010). There is also a notion that white males tend to have lower risk perceptions than white females, nonwhite males and nonwhite females across different hazards (cf. white male effect; Kortenkamp and Moore, 2011).

Unsurprisingly, gender effects have been found for environmental risks such as climate change (Finucane et al., 2000). Regarding MP, Deng et al. (2020) conducted face-to-face interviews and a structured questionnaire among residents of Shanghai (China) to investigate perceptions of MP, exploring willingness to reduce MP and its influencing factors. In this study, males had a lower average score than females on willingness to reduce MP emissions (Deng et al., 2020). Although differences in knowledge have been argued to be a reason for gender differences in environmental risk perceptions, females exhibited higher nuclear risk perceptions even in a sample of scientists (Barke et al., 1997). Therefore, it has been argued that there is more support for race and gender as explanations for differences in environmental risk perceptions than for differences in knowledge (Davidson et al., 1996).

Furthermore, environmental risk perception differs based on respondents' socio-economic status (Bickerstaff, 2004). People with a lower social status and fewer privileges tend to be in a position of less power and control. They are argued to be more vulnerable to economic stressors and therefore perceive the world as a more dangerous place (Finucane et al., 2000). A similar trend was reported by Deng et al. (2020), who noted that people with lower education had higher levels of worry about MP, while people with higher education were not as concerned. The authors argued that this was due to a more comprehensive understanding of MP in the latter group, which in turn might have reduced unnecessary concerns. Nonetheless, another study by Henderson and Green (2020) concluded that people with high environmental awareness are also more concerned and know more about MP.

## 3.2 Knowledge and reasoning

It is a common finding in the literature that laypeople and experts tend to differ in their level of perceived risk (Savadori et al., 2004; Siegrist et al., 2018). Sjöberg (1998) classified comparisons of experts' and laypeople's risk perceptions into three types: similar assessments for well-known risks; lower risk perceptions by laypeople for hazards which they have some control over, such as smoking or drinking; and lower risk perceptions by experts for complex topics such as nuclear power. These differences can be accounted for in part by aspects of the psychometric model (Slovic, 1987), including familiarity, controllability, and knowledge. The knowledge deficit model argues that if laypeople increased their knowledge, they would reach similar conclusions to those of experts; therefore, general knowledge and risk perception should correlate (Bubela et al., 2009). In its simplest form, however, the knowledge deficit model has not garnered much empirical evidence, and there is research that casts doubt on it (Kellstedt et al., 2008).

Regarding the issue of MP, in the study by Deng et al. (2020), the majority of people became worried or even overly worried when informed about possible impacts of MP, and increased knowledge about the issue was also associated with a greater willingness to take action to tackle the problem (Deng et al., 2020). Moreover, Henderson and Green (2020) investigated people's knowledge and understanding of MP in the United Kingdom. Particular focus was placed on the role of the media in framing perceptions, involving participants with no knowledge of MP as well as participants with particular interest in MP. The findings shed light on the importance of environmental awareness and how lack of awareness of the plastics problem represents a barrier to change (Henderson and Green, 2020). These findings highlight the importance and benefits of citizen science activities, which can raise awareness and knowledge about plastic litter. For instance, participation in beach clean-ups and other coastal activities has been shown to be associated with pro-environmental intentions and higher marine awareness (Wyles et al., 2017).

Recent findings by Kramm et al. (2022), showed that 80% of the German public had heard of MP, hence indicating that the public is becoming more aware of MP. The same investigation also found that level of education was important for MP awareness, since 90% of people considered to have a high level of education reported having heard of MP, whereas only 65% of those with low education reported having heard of them. Their results also indicated that higher environmental awareness tends to be associated with higher risk perceptions and that the more frequently one hears about MP, the higher the perceived risk of MP (Kramm et al., 2022).

According to a study by Grünzner, Pahl, White and Thompson (2021), experts (researchers working primarily on plastics) are more highly concerned about the risks of MP for the natural environment than they are about their risks for human health. Accordingly, MP have often been depicted in the media as something to be concerned about, as a risk for the environment (Völker et al., 2020). Nonetheless, some recent reports show that laypeople are highly worried about MP risks to the natural environment (European Commission, 2020), but also quite concerned about possible health risks (German Federal Institute for Risk Assessment, 2020).

People with higher levels of scientific reasoning have been found to be more likely to perceive risks consistently with the scientific evidence regarding those risks (Siegrist and Árvai, 2020). Nevertheless, risk perceptions among people with high scientific reasoning ability may not correspond to the actual scientific evidence if people have already made up their minds that the hazard is of high or low risk (Drummond & Fischoff, 2019).

### 3.3. Fairness, value orientations and worldviews

Regarding perceptions of environmental risks, people tend to care less about statistics, such as the number of casualties due to a hazard, and more about issues such as justice, fairness and duties to future generations (Moore, 2009). Within the psychometric model, the dread component of risk contains aspects related to ethical issues resulting from the unequal distribution of and lack of informed consent regarding risk exposure (Slovic, 1987). Additionally, moral evaluations of risks have proven to be a strong predictor of acceptability and perceived risk (e.g., Sjöberg and Drottz-Sjöberg, 2001); likewise, environmental injustice has been found to predict risk perceptions (Satterfield et al., 2004).

Cultural worldviews are defined as the pattern of beliefs and value orientations shared by people in a collective, or orienting inclinations which guide thoughts and behaviors (Mead and Mëtraux, 1954). Such worldviews are argued to have a strong influence on risk perceptions; individuals and collectives ascribe to one or a set of prominent value orientations, namely hierarchism, individualism or egalitarianism (cf. cultural theory of risk; Douglas and Wildawsky, 1982). Later research expanded value orientations to include egoism, altruism, and most interestingly for environmental risks, biospherism (e.g., De Groot and Steg, 2007). These studies have pointed to a weak relationship between worldviews and risk perceptions overall, albeit with two particular environmental hazards as noteworthy exceptions: nuclear power and climate change (Siegrist and Arvai, 2020). On another note, some people hold beliefs that lack scientific basis, such as so-called "New Age beliefs" (Sjöberg and Wahlberg, 2002). Sjöberg and Wahlberg (2002) investigated risk perception in relation to these beliefs, including traditional folk superstition, belief in paranormal phenomena and use of alternative healing practices. Such beliefs explained 15% of the variance in perceived risk (Sjöberg and Wahlberg, 2002). People with such beliefs tend to hold higher risk perceptions regarding environmental hazards such as climate change and nuclear waste (Siegrist and Arvai, 2020).

There are no studies on perceptions of MP that have explored value orientations or worldviews. Nevertheless, in studies of the risk of nuclear power, altruistic and biospheric values tended to be negatively associated with perceived risks (Siegrist and Arvai, 2020). For climate change, on the contrary, biospherism, and to a lesser extent egoism, have been positively associated with perceived risk (Van der Linden, 2015). Other evidence suggests that biospheric values may partially undergird climate change worry, whilst being directly and positively related to personal climate mitigation behaviors (Bouman et al., 2020).

## 4. Heuristics

Prospect theory (Kahnemann and Tversky, 1979) postulates that people tend to overweight small probabilities and underweight larger probabilities, depending on the type of decision they are making. Specifically, people overweight small probabilities when simply presented with descriptions of these probabilities, yet tend to underweight small probabilities when they are learned through experience (Kahnemann and Tversky, 1979). It is important to mention that people often lack the in-depth knowledge needed to evaluate hazards comprehensively, as indicated by studies addressing technologies (Connor and Siegrist, 2011) and climate change (Shi et al. 2016).

The elaboration likelihood model (Petty & Cacioppo, 1986; for an application in the environmental context, see Meijnderset al., 2001) argues that lack of motivation or knowledge leads to usage of a peripheral cognitive route, where heuristics are prominent. Heuristics are argued to work through attribute substitution (Kahneman and Frederick, 2005). When evaluating a hazard, an attribute that is not cognitively accessible, such as the probability of being exposed to the hazard, it is substituted with an attribute that is more easily accessed, such as recollection of concrete examples of that hazard (Siegrist and Arvai, 2020). For example, someone is more likely to evaluate the hazard of plastic pollution based on number of the times they spotted plastic floating in the sea rather than the actual statistical probability of exposure to plastic pollution.

### 4.1. Availability heuristic

The availability heuristic is used when people utilize the “ease” with which examples or occurrences can be brought to mind to assess the probability of an event (Tversky and Kahneman, 1974). For instance, someone might assess the risk of MP negatively affecting the environment by thinking about how often they hear in the news that MP have been found in their local area. The availability heuristic has been examined with respect to environmental hazards such as flooding (e.g., Tanner and Arvai, 2018), with people who could remember floods perceiving higher risk compared to those who could not remember such events. One might speculate that use of this heuristic might similarly affect laypeople’s perceived risk when it comes to MP. Support is provided by literature indicating that this heuristic may influence risk perception regarding climate change (Demski et al., 2017).

### 4.2. Affect heuristic

The affect heuristic maintains that the affective component elicited by a hazard influences risk perception (Finucane et al., 2000). People are argued to base their judgements about risks and benefits on their affective reactions (Slovic, 1999). It is further argued that there is an affect “pool” that contains positive and negative markers associated with all mental images (Slovic et al., 2004). Studies investigating this principle suggest that the valence of spontaneous associations is associated with risk perceptions and acceptance of risk (Siegrist and Arvai, 2020). The problem is that the affect heuristic might result in biased judgements (Nakayachi, 2013) by leading people to ignore information that would have been useful to formulate more accurate risk judgements (Sunstein, 2003). Accordingly, one possible explanation for the fact that people have been reported to perceive MP as more harmful than what the scientific evidence appears to indicate at this stage (Catarino et al., 2021) could be that people might associate MP with a negative affective component. Thus, people might be biased to think negatively about MP impacts and ignore certain information, in this case current uncertainty about the impacts, particularly on human health. Furthermore, questions about the causal direction of these associations can be posed. It is hard to exclude the possibility that risk perception might drive affective responses and not the other way around (Siegrist and Arvai, 2020).

### 4.3. Natural-is-better heuristic

In Western countries, nature is generally perceived as benevolent (Scott and Rozin, 2020). The natural-is-better heuristic is defined as neglecting the positive effects of human intervention and negative impacts of natural processes (Siegrist and Hartmann, 2020). Research in this vein shows that synthetic chemicals are much more negatively perceived than natural chemicals (Saleh et al., 2019), especially among individuals with high biospheric values (Campbell-Arvai, 2019). It follows that people might evaluate the issue of MP more negatively because they result from a human process, reducing naturalness. Supporting evidence stems from studies showing that MP are indeed perceived quite negatively (e.g., Deng et al., 2020) and that microbeads are perceived as an “unnatural”, unacceptable risk (Anderson et al., 2016).

## 5. Emotions

Risk perception used to be seen as exclusively cognitive, and emotions were not considered in this field for a long time (Böhm and Brun, 2008). An early study by Johnson and Tversky (1983) showed that people’s current mood affected their risk judgements, highlighting that people hardly ever react to threats in an emotionally neutral state, and emotions affect how they perceive risks. Emotions have since then come to be considered important factors that affect risk perceptions and evaluations (Böhm and Tanner, 2019). The previous section discussed how affect might root judgements about risks and benefits; however, there is an important distinction between general affect and specific emotions or appraisals (e.g., Lerner and Keltner, 2001).

Emotions can be connected to complex reasoning; each emotion carries a certain meaning and reflects a cognitive structure or viewpoint (Böhm, 2003; Böhm and Pfister, 2000, 2017). For example, worry anticipates that something bad might happen in the future; outrage involves assigning blame to other people; disappointment means that an outcome has fallen short of expectations; regret arises from a sense of responsibility; pity is a social emotion; guilt is more focused on ourselves and our own actions, when we feel we have acted in a way that violates a moral norm; fear is similar to worry because it has to do with anticipating future harm, but is more short-term and intense; hope reflects the belief that there is still a chance to achieve positive outcomes; and lastly, pride is felt when something has been accomplished (Böhm, 2003; Böhm and Pfister, 2000, 2017). Specific emotions are often explained through the appraisal theoretical framework (Frijda, 2007).

Böhm and Pfister (Böhm, 2003; 2000, 2017) conceptualized a dual-process model of risk evaluation involving two fundamental appraisal dimensions linked to specific emotions, namely consequences and morality. Fear is an emotion related to consequences, whereas outrage and guilt have more to do with the perception that moral norms have been violated (Böhm, 2003; Böhm and Pfister, 2000, 2017). Each dimension is associated with characteristic behavioral tendencies. Typical consequentialist behavioral tendencies are mitigation and adaptation, while actions more tied to morality are punishment and redemption, targeting the actor or aggressor (Böhm & Pfister, 2017). A consequentialist focus could lead to judgements about the perceived risk of MP towards animals, which could trigger an emotion of fear and ultimately a behavioral tendency to help clean up a beach full of plastic litter.

Research indeed shows that some of the intuitive associations with MP tend to concern harmful impacts on wildlife (Deng et a., 2020; Henderson and Green, 2020). Since the release of MP in the environment is evidently due to human activity, deontological evaluations might also be more intense than for natural hazards such as flooding. This interpretation follows literature showing that deontological judgments tend to be more intense in cases of human rather than natural causation, whereas consequentialist evaluations tend to be more intense when the consequences affect humans as opposed to nature (Böhm and Pfister, 2000, 2017). Despite the scientific evidence being not yet clear with respect to harmful consequences of MP for human health (Catarino et al., 2021), the public has been repeatedly found to be worried about human health effects (Deng et al., 2020; Henderson and Green, 2020). It is because of this that MP might actually trigger both deontological (outrage, guilt, etc.) and consequential emotions (sadness, fear, etc.).

## 6. Mental Models

An important basis for people's risk perceptions is how they mentally represent the risk event in question (Bostrom, 2017; Böhm and Pfister, 2000, 2017). Such a mental representation, commonly referred to as mental model[3], is constructed from available information, of which the most important components are the causes and consequences ascribed to the risk event. person's mental model of MP may convey the belief that MP are released into aquatic environments by washing fleece and synthetic clothing and that they will result in harm to some fish species. Laypeople's mental models tend to be less structured than those of experts (Bostrom, 2017). Inaccuracies in their mental models can lead people to make errors, which in the case of plastic can be seen in the development and promotion of certain actions and policies not fully supported by scientific evidence (Catarino et al., 2021). Common approaches to capture mental models about a given risk event are surveys (Bostrom, 2017) as well as thought listing and image association tasks (e.g., Smith and Joffe, 2013). Themes are inductively derived from open-ended responses to questions. For example, one might tap into the first things that come to people's minds when thinking of the environmental hazard; additional content analysis might refer to psychological theories (e.g., Böhm, Doran and Pfister, 2018).

One manner to assess the utility of mental models is to employ them within a problem-solving or decision-making approach, a strategy exemplified by the mental model approach to risk communication (Morgan et al., 2002). The phases of this approach include, first, developing a conceptual model of the target system, such as MP, into a decision model representing how science may best inform policy and risk mitigation decisions. Hence, the conceptual model consists of decisions about risks and what could be done about them (Bostrom, 2017). Second, semi-structured interviews assessing mental models and related perceptions of the risks of the issue in question and how to mitigate those risks are content analyzed and compared to the decision model (Bostrom, 2017). The interview protocols often include a think-aloud task, inspired by think-aloud studies used in other mental model approaches (Ericsson and Fox, 2011), but primarily consist of prompts asking participants to talk about the hazard. The analysis of the interviews is conceptually linked to the decision model, but open-ended (Bostrom, 2017). Third, the interviews might inform the design of survey instruments to survey larger samples, ideally representative of the groups for whom risk communication strategies are being developed (Bostrom, 2017). Another way to assess mental models regarding environmental issues is based on systems modelling and entails experiments in which individuals solve tasks such as dynamic greenhouse gas problems (e.g., Moxnes and Assuad, 2012).

Regarding what people's mental representations of MP might look like, Dilkes-Hoffman et al. (2019) asked members of the Australian public to state the first two words that came to mind when they heard the word "plastic". The most frequent words or concepts were general environmental statements, waste, pollution, ocean impacts, and animal impacts. Participants placed the main responsibility for reducing plastic waste on industry, followed by government, and 80% expressed a desire to reduce their personal plastic use (Dilkes-Hoffman et al., 2019). Moreover, the study by Deng et al. (2020) in China found that MP seem to be viewed as accumulating mostly in the ocean. The respondents also referred to factory production of plastic particles as the main source of MP, although, overall, they did not seem to be fully aware of the origin of MP (Deng et al., 2020). In addition, a UK study by Henderson and Green (2020) reported that most respondents were unaware of MP, although environmentally conscious individuals had heard about microbeads through media reporting on new regulations. While some people made a connection between their personal use of plastics and ocean pollution, they appeared unable to define the link between macro- and microplastics (Henderson and Green, 2020).

The few existing studies on perceptions of MP indicate considerable misconceptions, such as the recurrent association of MP with plastic islands (Henderson and Green 2020), and that an important share of the public seems to still be unaware of MP (Deng et al., 2020; Henderson and Green, 2020) – even though MP awareness is on the rise (Catarino et al., 2020). It is because of this that one might speculate that laypeople's mental models of MP are inaccurate. Notably, laypeople most commonly associate plastic and MP with pollution in the environment in general and the ocean in particular (Dilkes-Hoffman et al., 2019). Laypeople seem to often fail to recognize that MP also migrate among the atmosphere, freshwater, soil and different creatures (Bin et al., 2020). Further research could investigate whether people are able to understand that MP can also be released into these environments and the impacts this could have, such as harmful effects on wildlife. Regarding human health effects, the public appears to be very concerned about these impacts, despite the fact that scientific evidence for such effects is still unclear (Catarino et al., 2020).

Plastic particles from factories are the main source of global plastic waste (Boucher and Friot, 2017), and the public has reportedly made associations between these particles and MP (Deng et al., 2020). It could be that the majority of the public understand that these particles are the main source of MP, as Deng et al. (2020) argued. Nonetheless, there are various other sources of MP that the public generally seems not to be aware of. For instance, the decomposition of synthetic textiles is another important source of MP in the ocean (Boucher and Friot, 2017), although the public does not make this association often (Deng et al., 2020). Additionally, the public often does not associate individual plastic consumption with the release of MP and thus ocean pollution (Henderson and Green, 2020); instead, they often attribute responsibility to industry and government (e.g., Dilkes-Hoffman et al., 2019).

Public awareness of MP is increasing (Catarino et al., 2021). People are becoming more frequently exposed to the topic through the media, which is why people's awareness of the issue may continue to rise in the future. Media storytelling might indeed have a central role to play in shaping public understanding and bringing the topic to public attention in powerful ways (Henderson and Green, 2020). Employing a mental model approach to risk communication may provide valuable insights into how to address the gap between experts' and laypeople's knowledge (Pahl and Wyles, 2017). The mental models elicited from this research can be used to adapt messages to communicate the different risks posed by MP, and such communication can be evaluated via surveys or focus groups (Pahl and Wyles, 2017).

## 7. Conclusions

MP are a global environmental challenge that appears to increasingly concern both the public and academia. As an environmental risk, there are characteristics of MP as a hazard that influence people's risk perceptions. They are likely to be considered dreadful hazards given their global scale and potential impacts on animals and plants. Moreover, they are likely to be perceived as an unknown hazard, given that they are quite new, not well understood by science and not easily observable. This, together with the fact that they are caused by humans, might contribute to the high levels of perceived risk that have been reported.

Nonetheless, there are numerous relevant individual-level variables that can also shape MP risk perceptions. Socio-demographic characteristics, such as gender and level of education, have been shown to predict different levels of perceived risk of MP. Higher levels of knowledge about the issue tend to be associated with higher risk perceptions, even sometimes leading laypeople to be overly concerned. Perceivers' worldviews and values have also been reported to affect risk perceptions, among which biospherism is particularly relevant for environmental risks such as MP. Other potential sources of influence include the use of heuristics as opposed to more complex information processing, particularly the availability, affect and natural-is-better heuristics.

Emotions are another important factor that affects risk perceptions, and MP might trigger both consequentialist and moral emotions, which in turn trigger different judgements and behavioral tendencies. Lastly, how people mentally represent MP in terms of, amongst other things, its causes, consequences, and possible solutions, that is, people's mental models, might also affect risk perceptions of MP.

Given the few studies on MP risk perception due to the infancy of the field, it is difficult to make solid claims about how MP risk perception is formed. Nonetheless, research on MP is increasing exponentially, including interdisciplinary projects that combine findings from the natural sciences with insights from the social and behavioral sciences. This will deepen our understanding of what determines people's perceived risk of MP and allow us to effectively tackle this global challenge.

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