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Analytical Methods

ARTICLE

The Human Dimension: How Social and Behavioural Research Methods Can Help Address Microplastics in the Environment

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The present paper illustrates the breadth of research methods in the Social and Behavioural Sciences and how these may be applied to the issue of environmental microplastics. Microplastics are a human-caused problem and we need to understand the human dimension in order to address it. Nine key points are emphasised in this paper and follow from the key observation that humans, through their perceptions, decisions and actions, are pivotal to the issue of primary and secondary microplastics in the environment: 1) Human perception and behaviour can be subject to systematic and rigorous scientific study, using theory-based hypothesis testing, measurement and statistical analysis; 2) Qualitative methods can explore new areas of research and provide novel, in-depth insights; 3) Best practice and recommendations exist for measuring social data; 4) Quantitative cross-sectional approaches can test how important social factors are for key outcomes (e.g., the role of perceived risk, values, social norms for behaviour); 5) Experimental quantitative approaches can compare randomised groups and study cause-effect relations; 6) Certain limitations and challenges are unique to research with people; 7) Communications and interventions (e.g., change campaigns, new regulation, education programmes) should be developed based on scientific insights into human thought and behaviour and then evaluated systematically; 8) Social researchers should work towards developing standardised tools and protocols; and 9) Social research on microplastics and its determinants specifically is in its infancy and a number of important research questions remain to be addressed.

Introduction

Since the beginning of plastic development and production over 60 years ago, microplastics' entry to the natural environment (as primary or secondary microplastics) is undoubtedly entirely caused by humans. To understand microplastic pathways and to reduce quantities in the natural environment, we need to understand this human dimension by applying social research methods. The human dimension in microplastics is threefold: people contribute to the problem, they can help address it, and they may experience negative impacts of microplastics in the environment. First, people design and make products containing plastic materials, they buy products made with or packaged in plastic, and they dispose of the resulting waste, which can enter the environment from disposal behaviours, sewage outlets, waterways and by being blown from land fill sites [1, 2]. On the reverse of this, people are also the answer to the problem, through policy and consumer action (e.g., petitions to cosmetic companies regarding microbeads; avoiding certain products; petitions to governments to establish regulation) and

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individual behaviour (including disposing of waste responsibly and actively taking part in beach cleans). Organised pressure groups can run wide-reaching media campaigns, and decision makers in industry and retail may volunteer reduction programmes they deem morally right and viable (e.g., cosmetic companies' responses to the Beat the Microbead campaign, and a UK supermarket's voluntary plastic bag charge prior to national legislation). The third and final aspect is that humans can also be negatively affected by plastic litter and microplastics. For example, seeing or knowing about small plastic litter items may undermine health and wellbeing benefits ordinarily received from visiting the coast, and a potential concern that microplastics are in seafood could reduce seafood consumption and its associated health benefits.

Whilst people are central to marine litter and microplastics, research on the human dimension is underresearched. There is growing research on macro-sized items, such as studying littering patterns [3], reviewing waste policies and interventions [4], and investigating the impacts of litter on coastal visitors [5, 6]; however there is very little social research specifically examining microplastics [7, 8].

The Social and Behavioural Sciences, and especially the authors' home discipline Psychology, focus on the systematic study of the human mind and behaviour. Psychology uses a range of empirical methods to collect data that explain perceptions and behaviour, develop theories and inform interventions for behaviour change (http://www.apa.org/action/science/; see Figure 1 for a simplified method overview).

The present paper aims to be a primer for natural scientists interested in using Social and Behavioural research methods, and to guide future social research. We summarise and discuss a selection of research methodologies that can produce insights that will help mitigate environmental microplastics. We will illustrate the methods with selected studies on plastic use, waste management and recycling. While inspired by interdisciplinary collaborations and discussions over the last six years in the areas of marine litter, microplastics and well-being from coastal environments, this short paper is by no means exhaustive and reflects our particular experience and background.

Nine key points are emphasised in this paper and follow from the key observation that humans, through their perceptions, decisions and actions, are pivotal to the issue of primary and secondary microplastics in the environment.

1. Human perception and behaviour can be subject to systematic and rigorous scientific study, using theory-based hypothesis testing, measurement and statistical analysis;

2. Qualitative methods can explore new areas of research and provide novel, in-depth insights;

3. Best practice and recommendations exist for measuring social data;

4. Quantitative cross-sectional approaches can test how important social factors are for key outcomes (e.g., the role of perceived risk, values, social norms for behaviour);

5. Experimental quantitative approaches can compare randomised groups and study cause-effect relations;

6. Certain limitations and challenges are unique to research with people;

7. Communications and interventions (e.g., change campaigns, new regulation, education programmes) should be developed based on scientific insights into human thought and behaviour and then evaluated systematically;

8. Social researchers should work towards developing standardised tools and protocols;

9. Social research on microplastics and its determinants specifically is in its infancy and a number of important research questions remain to be addressed.

1. Studying human perceptions and behaviour: A brief overview of relevant concepts

Just like other sciences, psychological research on humans aims to identify general principles and processes. In this case, the focus is on explaining and predicting human thought and behaviour. Many competing yet partly overlapping theories exist that cannot be reviewed here (see Darnton [9] for an overview of behaviour theories). As an example, Kloeckner [10] recently tested an integrative model, combining data from 56 data sets targeting different environmental behaviours. He concluded that *intentions* ("I will do this"), *perceived behavioural control* ("It is up to me whether I do this rather than other people or contextual factors") and *habits* (behaviours that have become automatized through repetition) were the best direct predictors of behaviour. *Attitudes* (favourable or unfavourable evaluations), *norms* (what is seen as commonly done by others), *responsibility* (ascriptions of who should deal with a problem), *awareness of consequences* (knowledge about impacts), and *values* (general trans-situational goals such as equality or individualism) were shown to have indirect effects on behaviour. Further factors such as emotions and self-identity might play a role. Both negative (e.g., worry) and positive *emotions* (e.g., hope) have been linked to environmental behaviour [11]. Whether people see themselves as environmentalists could be important too, as *pro-environmental self-identity* has been shown to be associated with behaviour [12]. These ten social and psychological concepts can be measured and distinguished empirically (see Section 2) and provide a rich toolbox for changing behaviour beyond information and knowledge provision. Information is sometimes considered as the key factor for changing perceptions and behaviour by scientists outside the behavioural sciences ('we just need to tell them how bad it is and something will happen'). Informing people can be important, especially with emerging issues, but information alone is not very effective [13, 14]. Understanding the influences of these factors is important for understanding the human dimension and identifying the best ways for addressing environmental microplastics.

2. Qualitative social research methods: Exploration and depth

Although the behavioural sciences overall subscribe to a traditional scientific approach that tests theories and hypotheses and aims for insights that are generalisable across a population, qualitative methods make a valuable complementary contribution. Qualitative research typically focuses on the interpretation of naturalistic verbal data to explore and describe the experiences of a small number of people [15] but visual methods are also available. Qualitative research tends to be explorative open-ended rather than aiming to test specific hypotheses. It is aimed at eliciting in-depth thoughts on certain topics, without restricting responses via standardised question or response formats. This approach is flexible and questions or prompts can be adapted alongside the research process, to incorporate emerging ideas. Responses may be recorded in audio or video formats. Subsequent analysis typically identifies common themes or topics from the respective transcripts, which are represented through verbatim quotes.

Qualitative research can be undertaken with individuals (e.g., in-depth interviews [11]) and with groups of people (e.g., focus group methodology [7]). Both can be combined with the presentation of additional materials for the respondents to comment on. Anderson et al. [7], for example, ran focus groups on the topic of microbeads in personal care products and, about half way through the process, the researchers handed over samples of microbeads that had been extracted from personal care products [16]. This experiential approach, where participants could see and handle the evidence, elicited responses of shock and disbelief in the students, beauticians and even the environmentalists in this study.

Qualitative methods are particularly useful to begin research on emerging issues. If the target population is low in literacy, interviews or focus groups may also be preferable which rely less on written text. Finally, qualitative and quantitative elements can be combined. Open-ended questions can be included within more standardised quantitative questionnaire methods (see Section 3), in order to scope less developed ideas or ask respondents if they have additional ideas or feel something is missing. More systematic mixed-methods approaches have also been developed.

For example, the mental models approach to risk communication [17] combines qualitative research with quantitative surveys and experimental testing. It is particularly suited to eliciting and bridging expert and non-expert perspectives. Mental models are representations of perceived causal relationships, illustrated in diagrams that represent the most relevant factors, interactions and pathways. This approach was used to investigate risk perception of chemical hazards and health in the workplace to inform better communications [18, 19]. First, mental models were elicited from experts and workers using interviews [18]. These models were then used to adapt messages communicating the chemical risks, and a standardised quantitative survey as well as qualitative think-aloud group protocols were used to evaluate the new communication [19]. This staged approach provides a valuable blueprint that can be applied to any human-environmental risk issue, including environmental microplastics.

3. Measuring people's perceptions and behaviours: Quantitative approaches

If the aim is to obtain a large or even representative sample suitable for statistical analysis, typically more quantitative methods such as standardised surveys are used. Asking people directly what they think or do is a valid way of capturing perceptions and behaviour, for example to find out people's attitudes towards plastic bags (see also Section 6). Attitudes and perceptions are constructs in people's minds and there is no direct way of accessing them. We could ask people to rate their views on "plastic bags in general", perhaps using a 5-point response scale ranging from "very negative" to "very positive" that can be quantified by scoring the response, e.g., from -2 to +2. If we only wanted a rough snapshot of this particular attitude, this might well be sufficient, and if we asked the same question repeatedly, this would allow us to assess change over time or compare different groups of people.

Such single-question tools can be useful but they are crude [20]. The single question cannot cover different aspects such as type of use (e.g., for food or books), type of plastic bag (e.g., single-use vs. 'bag-for-life') and context of use (e.g., torrential rain vs. dry day). An improved tool would include a series of relevant questions that can be aggregated into a better combined score (because the error associated with each single item should be random [20]). Such data can also be 'factor analysed' to test whether a single or multiple dimensions underlie the responses (e.g., people may think differently about plastic bags in wet and dry conditions). Questions should also contain positive and negative statements to avoid biasing respondents. In practice, developing a good attitude survey is an iterative process from initial qualitative and conceptual research to repeated testing in different samples that assesses properties of the survey tool such as reliability and validity [21].

Good surveys require planning and piloting and should be supported by a researcher trained in social survey methods. Wording should be simple, jargon-free, unambiguous, focus on a single issue per statement (e.g., avoid "plastic bags are useful and cheap"), avoid double negatives and leading questions. Piloting can help avoid floor and ceiling effects in the target sample (i.e. where most people respond at extreme ends of the response scale). Response options as in the example above (or often "strongly agree" to "strongly disagree") are preferred as opposed to binary yes/no options or rankings because they allow more nuanced and free responding. Standardised tools also exist for some psychological concepts linked to pro-environmental behaviour, e.g., connectedness to nature [22].

An alternative that avoids limitations of the self-report methodology (see section 6) is the direct observation of behaviour. Sampling and observation protocols need to be carefully designed and recorded and inter-observer reliability should be established to ensure data quality [23]. For example, Jacovcevich et al. [24] observed consumer behaviour in several Argentinian supermarkets before and after plastic bag charges were introduced. As expected, consumer use of reusable bags increased and kept increasing for several months after the charge was introduced. Schultz et al. [3] observed the behaviour of nearly 9,000 US residents walking

through a range of outdoor public locations (e.g., city centre, fast food outlet). They found 4% of individuals littered, half of which was coded as being intentional rather than accidental. A second study focusing on observations of smokers found a much higher 65% littering rate for cigarette stubs.

Measurement of perceptions or behaviour may be more problematic than that of physical concepts such as salinity or temperature. Nevertheless by following some basic rules, useful social data can be gained. Quantifying psychological concepts in this way enables the description of large population samples in a relatively short period of time, it allows for comparisons between groups of people and for the evaluation of communications and interventions, and it is suitable for statistical analysis including meta-analysis [25, 26].

4. Towards explaining behaviour: Cross-sectional studies

Large-scale cross-sectional surveys as described in Section 3 can describe and compare a range of potentially relevant factors such as those reviewed in Section 1. For example, in the MARLISCO project on marine litter (marlisco.eu), we collected data on intentions, concern, how close people lived to the coast, how frequently they visited the coast, how frequently they noticed marine litter, their values and perceived social norms [27]. We also asked for participants' age, gender and education level as sociodemographic variables. We then used multiple regression analysis to see which of these factors most strongly 'predicted' behavioural intentions. The advantage of this type of analysis is that it looks at unique contributions of variables in the context of all variables (i.e., it controls for other factors in the model), and it allows for step-wise entry of variables in line with relevant theory [28]. In the MARLISCO study we found that the six most important predictors were concern about marine litter, own motivation to tackle the issue, frequency of noticing coastal litter, values, social norms and educational level. Less important but still significant predictors were age, gender and own perceived competence.

In this example, psychological predictor variables derived from previous research were at least as important as sociodemographic variables and, in some cases, more important. Similarly, Halvorsen [29] found that the strongest predictor for recycling behaviour was the perception that this was beneficial to the environment, whereas sociodemographic characteristics such as income were weak predictors, and contextual variables such as recycling services were moderately strong predictors.

Another, more sophisticated, option for analysing relationships between factors is Structural Equation Modelling (SEM [30, 31]). This is a collection of statistical techniques including regression that can cope with more complex relationships between factors including bidirectional and indirect effects. This approach can compare a theoretically informed model with the empirical model and assess the degree of fit. For example, Seacat and Northrup [32] applied SEM to curbside recycling behaviour and found good fit between the Information-Motivation-Behavioural Skills model [33] and data from

two US community samples. Finally, some data are nested with two or more levels of analysis, which may require Multilevel Linear Modelling. For example, responses may be given by individuals (level 1) in different schools (level 2) in different countries (level 3). Schultz et al. [3] applied a multilevel approach to observational data on littering behaviour and found that both person level variables (age and gender)‡ and environmental variables (specifically presence of receptacles and existing litter) explained a significant amount of variance in littering behaviour.

These cross-sectional quantitative methods and statistics allow us to compare the importance of different factors (see Section 1). However, in order to establish causality and to design effective interventions for behaviour change, experimental approaches are needed.

5. Experimental approaches

Experimental and quasi-experimental research designs that compare different groups can be applied to human processes in the laboratory and the field. Principles of randomisation and sampling apply similarly as in the natural sciences' experimental research (e.g., human participants are sampled from a population and randomly allocated to different conditions for a true experimental design [34]). If a full or even quasi-experimental design is not feasible, a before-after analysis can provide some data on change.

For example, Hartley et al. [35] found that environmental concern, understanding and self-reported actions increased in school children following an educational intervention, using a simple before-after research design. It would be even better to compare the treatment group to a control group without intervention, as potentially other external factors could account for the change over time. Poortinga et al. [36] ran a quasi-experimental study to test the effects of introducing a plastic bag charge in Wales, with English samples acting as controls (England introduced the charge later). Welsh respondents said they used their own bag more following the charge, and they supported the policy change more after it had been implemented than they did before. No 'spillover' effects were found on other pro-environmental behaviours but Welsh environmental self-identity increased, which could lead to other pro-environmental behaviours later. Poortinga et al. relied on self-report whereas other studies have used observational data to evaluate an intervention. For example, Cingolani et al. [37] tested the effects of an environmental campaigner approaching beach visitors in Argentina and verbally expressing the importance of keeping beaches clean as well as demonstrating the picking up of litter left by previous visitors. This personal intervention resulted in an average 35% reduction in litter observed on the morning following the intervention. Context, or environmental, interventions can also be tested with experimental designs. Keizer et al. [38] (Study 1) demonstrated how signs of a neglected environment can result in more littering: When graffiti was present in a town environment, 36% more people littered an unwanted flyer than when the wall was cleared of graffiti.

Experimental interventions such as these provide the best quality data for understanding behaviour and predictors of behaviour. The ultimate method to test causality is a randomised controlled trial (RCT) as used in medical research. Experimental studies can vary in rigour, sample sizes etc., whereas an RCT uses the strictest methodology including a pre-registration of protocol, hypotheses and planned analysis. This approach is beginning to be used in the Social and Behavioural sciences too (http://www.apa.org/science/about/psa/2015/08/pre-registration.aspx).

Experimental interventions can target perceptions and/or behaviour. In either case it is important to use past social research to inform the design and content of interventions. Intervention details regarding content and delivery should also be recorded carefully to allow future replication, comparison and analysis [39].

6. Challenges

Research on people faces a number of unique challenges. To optimise the quality of data collected, these need to be acknowledged and mitigated where possible. For example, when studying people's perceptions, solely asking about a particular environmental issue such as microplastics may distort perceptions as it increases the salience of this issue ('I hadn't really thought, but yes, I suppose this is important'). Mere questioning can sensitise respondents to an issue, which is desirable if the aim is to *change* perceptions but undesirable if the aim is to *measure* perceptions. Focusing on one specific issue may also be associated with considerable concern whereas outside the research context people only have a "finite pool of worry" ('microplastics might be important, but my children's education and my job are more important to me', see [40]).

More generally, respondents could be biased towards either helping or undermining the research. A helpful respondent might try to guess what the researcher wants to find or give answers s/he thinks are socially approved ('they must be interested in it, so I'll say it is important'; 'Most people think litter is bad so I'll say the same although I don't really care'). A small number of respondents might try to actively sabotage research by spoiling surveys; this can happen when the purpose of the research was not well explained or when a respondent suspects vested interests and lacks trust.

Self-reports of behaviour are widely used, because they are less costly and easier to obtain than objective measures. Kormos and Gifford [41] showed in a meta-analysis that self-reported behaviour was strongly correlated with objective measures of behaviour (average $r = .46$), yet this leaves a considerable amount of variance unexplained. This suggests that self-report can be used as an approximation of actual behaviour and for comparative purposes. Observations may be better for capturing behaviour objectively but need to be designed carefully because the mere presence of observers may change behaviour.

Finally, to ensure participant and researcher safety and well-being, ethical clearance should be obtained before any research, following professional guidelines. This involves submitting the proposed method and study materials to an institutional review board or ethics committee, demonstrating that a strict protocol will be followed throughout the research (e.g., obtaining consent from participants, maintaining data confidentiality etc.).

Research with humans has a range of unique limitations and challenges but using appropriate methods, these challenges can be minimised. Moreover, triangulation with different methods could be used to validate findings, e.g., checking whether self-report and observations, or qualitative small-scale and quantitative large-scale approaches produce the same conclusions.

7. Designing and Evaluating Interventions

The Social and Behavioural Sciences play a vital role in developing and implementing interventions, whether they aim to simply communicate about microplastics or change behaviour. These campaigns can target a reduction in littering, promote sustainable waste management, and encourage pro-environmental consumer behaviour. Understanding key factors in perception and behaviour (see Sections 1 and 4) is the first step in informing interventions that should then be evaluated systematically, ideally using experimental approaches (see Section 5). Behavioural scientists can make recommendations for proposed communications and interventions before implementation, and they can evaluate completed projects [42] although it is preferable to integrate evaluation from the start. *Process evaluation* tests a pilot implementation in terms of feasibility and picks up potential barriers to a wider roll-out whereas *outcome evaluation* tests whether an intervention achieves its aims.

Evidence-based recommendations exist for communicating environmental topics that can be adapted to microplastics communication [40]. Similarly, specific behaviour change tools and techniques are available and include goal setting, commitment, social norms, feedback, visualisation, personalisation, action planning, rewards and many more [39]. Although most evidence for these specific techniques to date comes from the health context, they are applicable to the context of microplastics, marine litter and wider environmental issues [26].

In practice environmental organisations and researchers have been extremely creative in designing campaigns that use volunteers and citizen science to monitor microplastics and reduce marine litter (see Zettler, this volume). In addition to assessing the effectiveness of these campaigns in terms of removing litter and collecting reliable litter composition data, it is also useful to evaluate the wider effects these campaigns have on the participants themselves in terms of increased awareness, follow-on intentions and behaviours and overall experience of the activity. Wyles and colleagues [43] allocated student participants to a beach clean or comparative activity (another citizen science activity or a coastal walk in the same area). All three activities were associated with positive mood and pro-environmental intentions but beach cleans were seen as uniquely meaningful. Enjoyment and meaning are two key constituents of overall well-being [44] thus this study suggests

that beach cleans can contribute to human well-being in addition to cleaning local coastal areas of litter. Evaluations of activities that target microplastics and marine litter should perhaps include a range of outcomes to capture the wider benefits.

8. Towards standardisation

Standardising analytical methods is just as desirable in the behavioural sciences as it is in the natural sciences. However, the research in this field is not developed enough to make firm recommendations, and standardisation may not always be feasible. Researchers should work towards standardisation for observations, measuring relevant concepts and documenting protocols to ensure a higher degree of comparability of social data. First, building on Schultz et al.'s [3] and Jacovcevic et al.'s [24] work, an agreed observation protocol could be established for both littering and consumer behaviour. This would include detailed instructions regarding sampling and timing and specifying target behaviours to be used in different countries and contexts. If documented in such detail (possibly with additional training), observers around the world could contribute to a global littering behaviour database, for example. In future this approach could be extended to other relevant observable behaviours. Second, existing measures of psychological concepts should be considered, especially if they have been used in large-scale surveys. For example, the International Social Survey Programme has measured environmental concern in the same way in 33 countries over many years [45], and there are standard measures for human well-being (e.g., OECD [46]). Finally, as mentioned before, protocols of activities and interventions with people should be documented carefully (for example building on existing protocols used by Keep Britain Tidy; Keep America Beautiful; the Marine Conservation Society; Hidalgo-Ruiz & Thiel [47, 48] and others) in order to allow comparability of resulting research data (both for social and marine outcomes).

9. Future Social Research

The Social and Behavioural Sciences can make important contributions to addressing the problem of marine microplastics, through helping us understand people's perceptions of the risks and benefits of plastic materials, communicating effectively about this emerging issue and designing and evaluating communications and interventions using rigorous scientific approaches. There is a need for future research to investigate 1) Consumer attitudes and choices (e.g., regarding packaging or products containing microbeads), 2) Determinants of waste management and disposal behaviour (recycling, littering etc.), 3) How perceived microplastics risks might affect seafood consumption, 4) optimising engagement and their beneficial impacts on people (e.g., citizen science / beach cleans), and 5) Decision making in commercial and policy contexts by those in power (what determines new policies; what's the role of public acceptability; how can we elicit consensual solutions, see e.g., Lee at al.'s work on participatory workshops in Korea [49]), to name but a few themes. In terms of methods, future research should build upon the strong theoretical and measurement approaches presented but could also explore the power of big-data

analysis in helping us understand the human dimension (e.g., Vespignani [50]). Finally, more research should be undertaken that couples environmental and social data (e.g., Slavin et al. [51]).

Conclusions

This paper is based on insights from interdisciplinary work integrating natural and social science approaches and demonstrates how we can work together to tackle the global challenges of today. It is not enough to describe environmental problems without considering the role of people in the process. The Social and Behavioural Sciences offer theories and tools for a systematic study of the human dimension in terms of perception, communication and interventions to change behaviour. This large body of research and expertise can play a crucial role in tackling environmental microplastics. In sum, our recommendation is that strategies for reducing marine litter and microplastics should be guided by behavioural science, in addition to natural science [1].

Acknowledgements

Notes and references

‡ Note that these were the only two person variables that could be estimated; perceptions, attitudes, motivations etc. cannot be gathered from observations (see Section 3). Age and gender explained less than 1% of variance at the person-level, leading Schultz et al. [3] (p. 37) to conclude that other person-level variables are required to explain littering behaviour (such as those explained in Section 1).

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