

Chemophobia in Europe and reasons for biased risk perceptions

Very few consumers are aware that chemistry and synthetic chemicals are indispensable in making everyday goods because the products that people buy — such as cell phones, cars and processed foods — are typically far removed from the raw chemicals used in their production.

Michael Siegrist and Angela Bearth

The human and economic progress that has occurred over the past couple of decades is remarkable¹. These advances have only been possible because of an extensive division of labour, but one downside of this development is that consumers typically lack detailed knowledge about how the goods they use in their daily lives are actually produced. This leads laypeople to rely on mental shortcuts when evaluating associated benefits and risks, especially when it comes to chemicals, for example.

To better understand consumers' knowledge and risk perception related to chemicals, we conducted a survey across eight European countries: Austria, France, Germany, Italy, Poland, Sweden, Switzerland and the United Kingdom². There were a total of 5,631 participants, with roughly 700 from each country. The prevalence of some unfounded fears evoked by chemicals among the public in these countries (Fig. 1a) has resulted in the impossible desire of many respondents to live in a world where chemical substances do not exist. Similarly, many claim that they do everything they can to avoid chemical substances although they clearly — and most likely unknowingly — rely extensively on products, from food to cell phones, that would not be possible to manufacture without synthetic chemicals.

Realizing that we use different types of decision-making processes seems to be helpful in understanding the differences between the risk perceptions of laypeople and experts. It has been suggested that people rely on two different cognitive systems when making decisions: experiential and analytic³. The analytic system is slow and requires elaborate information processing, whereas the experiential system enables people to make quick decisions. Toxicologists predominantly use their analytic systems when conducting risk assessments. However, as lay toxicologists, consumers rely instead on simple heuristics. In daily life, this approach often results in good, or at least acceptable, decisions. Yet, when it comes to judging toxicological principles and the safety of chemical substances, the use of heuristics may lead people to make biased decisions. Laypeople rely on at least three rules of thumb when evaluating chemicals: The 'natural-is-better', the 'contagion' and the 'trust' heuristics. Lack of knowledge and a reliance on these mental shortcuts may be the cause of the public's unease, and even fear, of synthetic chemical substances that are present in their environment, a phenomenon that has been labelled 'chemophobia'⁴.

The term, 'natural', evokes almost exclusively positive emotions in people from

Western countries⁵. Consumers often rely on the natural-is-better heuristic, which results in a preference for natural foods⁶ and a much more negative perception of synthetic chemicals when compared with chemicals of natural origin². This manner of thinking also results in a biased risk perception of cleaning products that are labelled as being 'eco'⁷. Laypeople will typically evaluate an 'eco' drain cleaner to be much safer than a regular drain cleaner, despite the two products containing very similar ingredients and the same warning labels.

It only requires the presence of a small amount of a substance that is seen to be unnatural — and thus associated with negative outcomes — to have a significant effect on perceived naturalness⁸ or perceived risk². That people rely only on the act of contamination (or contagion) when assessing the properties of a given substance, while ignoring the quantity of that substance, can be referred to as the contagion heuristic. Relying on this heuristic, laypeople show a surprisingly robust insensitivity to dose–response relationships^{2,9}. For many people, a chemical substance is simply viewed as being either safe or dangerous; the link between any potential hazard to human health and the exposure route or dosage is not appreciated. For example, fewer than a quarter of

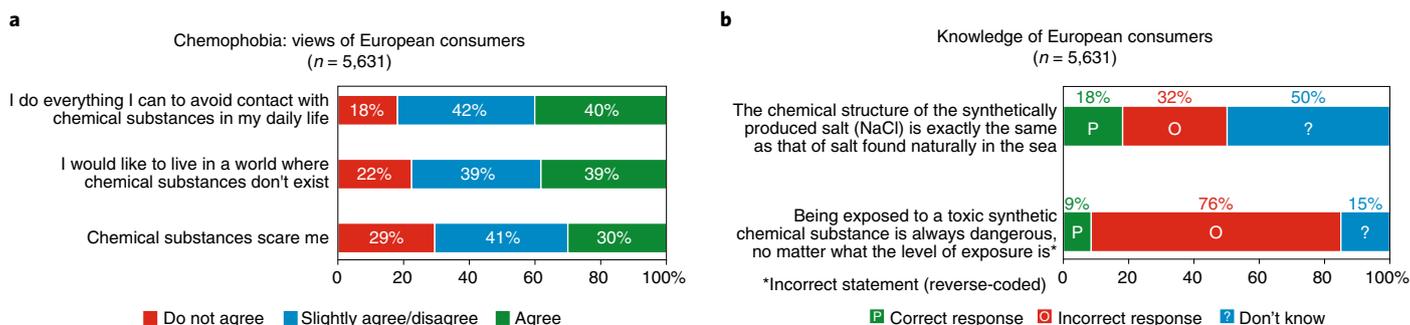


Fig. 1 | Surveying chemical knowledge in eight European countries. **a**, Responses to three questions designed to provide a measure of chemophobia. **b**, Responses to two questions designed to gauge the chemical knowledge of the consumers taking part in the survey. In each case the results are shown for the pooled sample across eight countries and the results are taken from the study reported in ref. ².

respondents in our survey correctly agreed that a small amount of a toxic chemical substance in a consumer product is not necessarily harmful². Thus, there exists a fundamental conflict between people's insensitivity to dose–response relationships and the fact that there are safe limits of exposure to a toxic chemical substance.

If someone possesses only limited knowledge about a given hazard, they may rely instead on the trust heuristic¹⁰. The trust heuristic states that people rely on their trust in stakeholders and communicators to determine the associated risk. Trust is based on the judgement of similarities in intention and values. Therefore, perceived similarity — rather than any established or certified competence — determines whom people trust. Trust or distrust in the chemical industry, in environmental non-governmental organizations or even in celebrities who are critical about chemicals, may influence laypeople's perception of chemicals.

The responses to our survey revealed that all three heuristics shape laypeople's perceptions of chemicals. People who are aware of the dose–response relationship and who understand that the distinction between synthetic and natural chemicals is irrelevant when assessing chemical risk are not as chemophobic as individuals who lack such knowledge². Those who possess a basic knowledge of toxicology do not need to rely on the natural-is-better and the contagion heuristics. Furthermore, consumers who trust their national agencies to successfully control chemical risks display fewer chemophobia traits compared with those who distrust the authorities. Other factors also affect how chemicals are

perceived. For example, people who are extremely concerned about their health are more likely to suffer from chemophobia than those who have fewer such worries². It also appears to be the case that women and older adults tend to display higher levels of chemophobia compared with men and younger individuals².

In 2015, the Royal Society of Chemistry initiated a study¹¹ on public attitudes towards chemistry and science. Our findings^{2,12} predominantly confirm the findings of their public survey: most respondents feel uninformed about chemistry, are not able to recall concrete applications or benefits and express neutral-to-negative associations to chemicals. A surprising finding was that the UK public's attitudes were significantly less negative than expected by chemists. This seemingly stands in contrast with our findings. However, our study focused more strongly on people's perceptions of chemical substances in their daily lives, whereas the study by the Royal Society of Chemistry focused more on chemistry as a scientific discipline.

It is not our intention to propagate a naïve deficit model postulating that a lack of knowledge is the only reason for negative perceptions of synthetic chemicals. Nevertheless, there is strong evidence to suggest that relevant knowledge is an important factor in decreasing chemophobia. The responses plotted in Fig. 1b suggest that only a minority of European consumers are able to correctly answer relatively simple chemistry-related questions. These findings are, in our opinion, a call to action.

Improving scientific literacy by strengthening all levels of science education

and developing creative informational campaigns to educate the public is an important goal. Widespread chemophobia may not only result in non-optimal policy decisions, but could also stifle innovation. Chemists and toxicologists should, therefore, be investing in ensuring that as many people as possible appreciate that the distinction between natural and synthetic chemicals is not useful for assessing risk, and that it is the dosage that makes a chemical poisonous. A better understanding of these basic principles of toxicology will hopefully reduce chemophobia and lead to better — and more informed — decisions all round. □

Michael Siegrist* and Angela Bearth

Consumer Behaviour, Institute for Environmental Decisions, ETH Zurich, Zurich, Switzerland.

*e-mail: michael.siegrist@hest.ethz.ch

Published online: 7 November 2019

<https://doi.org/10.1038/s41557-019-0377-8>

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Author contributions

The manuscript was jointly prepared by M.S. and A.B.