PRINCIPIA **29**(1): 1–20 (2025) doi: 10.5007/1808-1711.2025.e103113
Published by NEL — Epistemology and Logic Research Group, Federal University of Santa Catarina (UFSC), Brazil.

GROUPING APPROACHES TO PFAS AND INDUSTRY FUNDING: A CASE STUDY ON THE FINDINGS OF A RECENT PANEL OF EXPERTS

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Abstract. Per- and polyfluoroalkyl substances (PFAS) are a large class of chemicals, whose carbon-fluorine bonds allow a wide range of industrial applications but also make them highly persistent. Since there is evidence about only a few of them and their properties may vary, one of the pressing issues regarding PFAS is how to group them for different purposes. In this paper, I aim to show how a recent panel of experts about grouping PFAS was co-opted in a way that favor the fluorine industry. The panel consisted of eleven experts, including authors renowned for views in conflict with fluorine industry regulatory approaches, answering questions through an online application. Its main results along with the experts' answers were published in 2022 in the journal Regulatory Toxicology and Pharmacology. Through a detailed analysis of all the material published and in dialogue with the literature about industry-funded research, I will present how choices in the design of the panel (*e.g.*, which kind of consensus the exercise could capture, the ways questions were framed or even changed), in textual analysis (*e.g.*, criteria for assembling opinions) and in the communication of the findings (*e.g.*, what gets included or excluded) were made in an industry friendly way affecting two specific grouping approaches. I conclude with some lessons about this kind of influence of industry funding.

Keywords: general philosophy of science • values in science • industry funding • per- and polyfluoroalkyl substances

RECEIVED: 30/04/2024 ACCEPTED: 19/09/2024

1. Introduction

Some of the worrying consequences about industry-funded research are known to have occurred on the case of the large class of synthetical chemicals named per- and polyfluoroalkyl substances (PFAS). Back in the end of the 20th century, a family lawsuit against one of the main PFAS manufacturers - DuPont - led not only to a large settlement-funded study, which was able to conclude how harmful one of the PFAS is, but also to making several industry documents publicly available. Among other things, they showed how the manufacturer, that disposed chemicals on the

river close to the family's cattle, did not disclose important information about actual or potential harms of their products. This scenario of *unseen science* delayed for decades crucial public awareness and preventable mitigatory actions (Richter; Cordner; Brown 2018).

Investigative journalists and scholars have been providing more instances of other negative influences of industry funding in research about PFAS. They include, for example, 3M company employees publishing a letter in a journal criticizing a study result that, nonetheless, was known by the company decades before and never shared (Lerner 2018b; Michaels 2020). To state in public the opposite of what is known in private is a common negative pattern in the context of industry-funded research (cf. Supran & Oreskes 2017). More subtle ways in which industry funding can negatively impact science include manipulating overall evidence by selectively funding friendly research or taking advantage of weaker regulatory frameworks in the Global South in ways that produces epistemic and ethical damages (Fernandéz Pinto 2019, 2021; Holman & Bruner 2017).

In this paper, I aim to contribute to the above literature by investigating how a recent panel of experts about grouping PFAS was co-opted in a way that favor the fluorine industry. This case is intriguing for two reasons. First, some of the panel experts are recognized for positions of conflict with the organization that — without their knowledge — funded the panel, the American Chemistry Council (ACC). Their presence on the panel was regarded as a signal of credibility of the results, as one can apprehend from a chemicals reporter at Bloomberg Environment's tweet.[1] Second, although industry negative influence on scientific panels is not a new phenomenon, the details about how it is done are hard to find (McGarity & Wagner 2008, p.181); here, however, it will be possible to detail how experts' opinions were selectively framed or even changed in ways that allies with the fluorine industry positions. In other words, this case analysis will allow a deeper understanding of industry co-option of non-sympathetic scientists. This investigation will be achievable because the panel occurred through an online platform called SciPinion and part of its data were published. This paper may bring, therefore, more clarity to philosophers and scientists about how to understand and deal with such strategies. It is then structured as follows.

In the next section, I present the theoretical background of my analysis. More precisely, in section 1.1 I quickly state the advantages and disadvantages of industry funding in science, mention three conditions under which industry funding is most likely to negatively impact science, and briefly comment on previous cases of industry influence in scientific panels. Then, in section 1.2, I explain the pressing debate about grouping PFAS and show how research about those chemicals satisfies the conditions of the last section. Moving on to the second section, I give a description of the object of my case study: "Grouping of PFAS for human health risk assessment: Findings from

an independent panel of experts" (Anderson et al. 2022); I also detail my approach to the material published and how I will restrict it to two theses related to grouping approaches. In the third section, I present my analysis of it, focusing on choices in the design of the panel, in textual analysis and in the communication of the findings. In the conclusion, I provide some lessons about this kind of influence of industry funding.

2. Theoretical background

2.1. Industry-funded research and scientific panels

Industry-funded research has potential positive and negative consequences. Potential positive consequences include, for example, innovations in both basic and applied research, and alleviating problems with reproducibility; some of its potential negative consequences were already mentioned in the introduction (cf. also Holman & Elliott 2018), but it is worth mentioning another one, the funding effect. The *funding effect* is the systematic tendency of industry-funded research to lead to favorable results, an effect that has been uncovered in several fields of research from clinical research to cost-effective analysis (Lundh et al. 2017; Xie & Zhou 2022). Reasons for the funding effect are still a topic of discussion, but some might be design bias (*i.e.*, designing studies in ways that are more likely to generate favorable results, such as using non-sensitive animal models) or publication bias (*i.e.*, withholding the publication of negative results).

To put under a cloud of suspicion all industry-funded research because of its potential negative consequences is not reasonable. With that in mind, some scholars have proposed conditions under which industry funding is most likely to negatively impact science. Kevin Elliott (2013), for example, proposed three conditions: (i) scientific findings are not yet stabilized; (ii) agents "have strong incentives to influence those scientific findings in ways that damage the credibility of the research" (Elliott, 2013), and (iii) agents that satisfy (ii) also have adequate opportunities to influence those scientific findings.

When (i)–(iii) are met, we have a reason to suspect that a specific study has been somehow compromised. Another way to state it is by using John Pollock's (1987) distinction between an undercutting and a rebutting defeater. Roughly speaking, while a rebutting defeater for a belief in a proposition P is a reason to believe in non-P, an undercutting defeater is a reason to doubt the epistemic support of P. Therefore, when conditions (i)–(iii) hold, we would have an undercutting defeater for the proposition which the research led to, but not a rebutting one. As I intend to show in the next section, research about PFAS satisfies (i)–(iii).

There are a lot of ways by which a specific study can be compromised when (i)–(iii) are met. One of the ways occurs by assembling a panel of experts to advance a favored outcome in a consensus statement. Consensus statements are important for policy makers because they gather scientific information about a pressing issue, information that otherwise would be diffused in the scientific literature; depending on the number of specialists involved, they are also harder to criticize than individual scientists' statements. It is not surprising, therefore, that industry has been influencing panels to favor its positions.

Although this can be illustrated by cases of federal science advisory panels in which some industrial scientists were inserted for specific purposes (*e.g.*, influencing the deliberations, gathering inside information, changing passages of the final report etc.; cf. Oreskes & Conway, 2010, p.87ss), more importantly to the present study are cases where industry creates its own scientific panel and promote it as an "independent" one. McGarity & Wagner (2008, p.194) give the following example of this strategy: a pet food manufacturer assembled a panel whose conclusion was the safety of its production plants just after a US national recall of many pet food products; this conclusion was disseminated in fifty-nine newspapers, but there was no mention that four out of seven experts of the panel had conflicts of interests. It is also important to note how the panels "are sometimes convened by nonprofit groups whose industry ties are known only to insiders" (McGarity & Wanger, 2008, p.195), which makes it difficult to visualize industry influence.

The case study of this paper is an example of a panel funded by an industrial group, ACC, but convened by a third part, SciPinion. Although the ACC funding was not disclosed to the authors and in the paper it is stated that they had no influence, I will show how several decisions related to the design of the panel, in textual analysis and in the communication of the findings favors its positions. By saying that, I focus on the consequences of those decisions to the subject of this paper, so I will not be presupposing that it was anyone's intention (explicit or implicit) to do so. This way of framing my analysis allies with the understanding of a value-laden decision in science as a decision that has social consequences (Elliott, 2016).

2.2. PFAS and its grouping approaches

The idea of basing risk assessment or management on groups or classes of compounds is not new. It has been used by domestic and international regulatory agencies on cases such as pesticides or phthalates. Its main motivation is to alleviate the data-intensive and time-consuming pitfalls of the traditional chemical-by-chemical approach, such as the tendency to assume that chemicals with no data pose no risk and regrettable substitutions. Now, different aspects of chemicals can be used to form a group: their structural similarity, common adverse health outcomes with or with-

out the same mechanism of action, similar physical-chemical characteristics, common uses etc.. Therefore, there may be differences of hazard, for example, within compounds of the same class defined by other criteria (Maffini et al., 2023). This potential internal heterogeneity of grouping approaches is one of the obstacles that give rise to significant discussion, as the example of the PFAS also shows.

PFAS are a large class of synthetic chemicals. Depending on the definition adopted, its extension can vary from 600 to 4700 substances (Wallington et al. 2021). The vast majority is persistent, but other properties may vary (Cousins et al. 2020b). Most known PFAS such as perfluorooctanesulfonic acid (PFOS), $C_8F_{17}SO_3H$, and perfluorooctanoic acid (PFOA), $C_8F_{15}HO_2$, have been widely studied and linked to several adverse health outcomes, but there is scarce evidence about newer and replacing ones (Wang et al. 2017).[2] Elliott's first condition (scientific findings are not yet stabilized) is met, therefore.

Thanks to their C-F bonds, PFAS have properties such as water repellency and friction reduction and, consequently, have been widely applied since their synthetic creation in the 1940s. A recent review lists 200 categories of use, from textile impregnation to guitar strings (Glüge et al. 2020). Even after restricting regulatory measures such as drinking water guideline levels in several states in the United States or the inclusion of some PFAS to the Annex A (elimination) or B (restriction) of the Stockholm Convention, there are problematic exceptions to it that allow products as the PFOS-based pesticide Sulfluramid in countries as Brazil (Nascimento et al. 2018), and the production of PFAS may have diminished in some countries but has increased hugely in others, such as in China (Lerner, 2016). Hence, Elliott's second condition is also met: because of its economic importance, agents have economic incentives to influence the research about PFAS in a way that harms its credibility.

Finally, previous cases about industry-funded research on PFAS also shows how Elliott's third condition is also satisfied: agents with economic incentives to damage the research have been having adequate opportunities to do so. This has been discovered thanks to the release of documents related to several litigations against PFAS main manufacturers, which showed instances such as an university professor funded by 3M who kept papers with negative consequences to the industry out of the scientific literature (Lerner 2018a) and of company scientists downplaying the worrying results of an internal study in a paper (Lerner 2018b). More worryingly, are the consequences of the non-release of several results and information, as I show next before turning to the specific discussion of grouping approaches to PFAS.

Due to the non-sharing of 3M studies about PFAS effects on the immune system since 1978, this angle of analyses had to wait thirty years to be addressed. What Philippe Grandjean, the researcher responsible for investigating it in the 2000s, stated about the situation is very illuminating: "Had I found out in 1978 that this industrial chemical was toxic to the immune system, I could see all sorts of examinations of

exposed kids that could be done, but I was not told, so it had to wait, [in] this case 30 years, before I turned my attention to this" (Grandjean *apud* Michaels 2020). Also, despite FluoroCouncil's - an ACC subsidiary that represents PFAS companies - affirmation that "[a]ny claim that there are minimal data publicly available on the hazards and risks of these substances [short-chain PFAS] is simply incorrect" (Bowman 2015, p.A115), this is far from being the case. As already discussed by other authors (Krafft & Riess 2015, p.205; Richter et al. 2021, p.12–13; Wagner & Gold 2022, p.140), legal instruments such as Confidential Business Information (CBI), which allows manufacturers to claim confidentiality about information about their products (*e.g.*, the structure of a chemical, the volume produced etc.) for competition reasons, have problematic consequences in this context.

For example, under the US Toxic Substances Control Act (TSCA), employees of the Environmental Protection Agency (EPA) that share CBI are subjected to criminal imprisonment and fines. Furthermore, even information related to TSCA's Section 8 (e), which requires manufacturers to report information of a substance that supports the conclusion that it "presents a substantial risk of injury to health or the environment", can be claimed as confidential. A review of 100 Section 8 (e) submissions for fluorinated chemicals from 2007 to 2015 found that 85% did not disclose the name of the chemical and 55% the name of the company (Andrews & Walker 2015, p.14). Therefore, scientists are either prevented from sharing important information with each other or do not have access to them at all, which not only harms science norms, such as openness and transparency, but also makes research on new chemicals, such as long-chain PFAS replacements, extremely challenging.

Given this scenario, it is important to note that grouping approaches to PFAS vary broadly but their potential impact on PFAS manufacturers is significant to the point that this theme became urgent for them. For example, the ACC recently published a document titled "PFAS Grouping: An Emerging Scientific Consensus" where they state that "(...) a proposal to regulate all PFAS as a single class is neither scientifically accurate nor appropriate" (ACC, 2022). They mention favorable statements by some regulatory agencies and scientists, and only one paper funded by them against a specific kind of grouping (Goodrum et al. 2020).

According to Cousins and collaborators (2020a), there are nine grouping approaches to PFAS which can be ranked in a precautionary scale based on two criteria; how many PFAS are grouped and data requirements. Decreasingly, we have: the p-sufficient approach, the persistence, bioaccumulation, and toxicity (PBT)/very persistent and very bioaccumulative (vPvB) approach, the persistent, mobile and toxic (PMT)/very persistent and very mobile (vPvM) approach, polymers of low concern (PLC), the arrowhead approach, the total organofluorine approach, the simple additive toxicity approach, the relative potency factor approach, and grouping only PFAAs with the same adverse effect, modes and mechanisms of action, and toxicokinetics.

For the purposes of this paper, only two are directly relevant due to their presence on the panel data: the p-sufficient approach, ranking first, and the total organofluorine approach, ranking sixth.

The p-sufficient approach was proposed by Cousins and collaborators (2019a) and was first applied recently by the State of California's Department of Toxic Substances Control (DTSC) (Bălan et al. 2021). It understands that PFAS either have highly persistent moieties or those that do not ultimately transform into persistent ones. Thus, all PFAS would be managed together. To specify management actions, one can distinguish between PFAS' essential vs. non-essential uses, as defined by Cousins and collaborators (Cousins et al. 2019b), defended by Kwiatkowski and collaborators (2020), and endorsed by 252 scientists in The Madrid Statement on Poly- and Perfluoroalkyl Substances (PFASs) (Blum et al. 2015). The Madrid Statement was criticized by a FluoroCouncil report in the following way: "The FluoroCouncil could support many of these policy recommendations if they were limited to long-chain PFASs" (Bowman 2015, p.A112).

The total organofluorine approach is currently used in Denmark. Total fluorine (TF) is a measure of "the sum of all fluorine as a surrogate for all inorganic and organic fluorinated substances in a sample" (Cousins et al. 2020a, p.1451). TF can be extracted using organic solvents (extractable organofluorine, EOF) or by a sorbent (adsorbable organofluorine, AOF); the extract is then combusted so that the released fluorine can be measured. Thus, it can be a fast way to screen whether there are low or high levels of PFAS in a sample. Furthermore, for risk guidelines, one can assume that the EOF/AOF concentration is equal to the concentration of the most toxic PFAS known, such as PFOA or PFOS. Notwithstanding, it is unknown which PFAS are represented, and it may also include organofluorine compounds that are not PFAS (Andrews & Walker 2015).

3. A first approximation to the case study: the entities at play and first worries

The material of my case study is the paper "Grouping of PFAS for Human Health Risk Assessment: Findings from an Independent Panel of Experts" (Anderson et al. 2022) and its supplementary data (110 pages).[3] The paper, published in *Regulatory Toxicology and Pharmacology*, reports the results of a panel of experts which happened through SciPinion's platform. SciPinion was founded in 2014 with the aim of, according to their website, "pooling the collective wisdom of the world's foremost experts to battle uncertainty, exposing their expertise to governments, industry and the public" (https://scipinion.com/about/). Regarding its platform, it is said that "[it] minimizes the bias and negative influences that often surround debates about

controversial topics".

The panel consisted of eleven experts and one topic lead expert. Six of the experts were affiliated with universities, and five plus the topic lead expert were independent consultants or affiliated with consultant companies. There were rounds of questions which the experts could answer and then comment on each other's responses anonymously. Questions were made by the topic lead expert, and, in one round, by each of the experts. The panel was funded by ACC, a trade association that represents chemical companies and with a long record of negatives influences in science, such as downplaying formaldehyde (*How the American Chemistry Council Sowed Uncertainty...*, 2017) and silica risks (Michaels, 2020; cf. also Goldman; Carlson; Zhang 2015). It is also worth mentioning that the paper has fourteen citations so far (03/21/2024) according to the Google Scholar database.

Through a first reading of the material, some worrying elements already appear. For example, C. R. K. and S. M. H, owners of SciPinion and co-authors of the paper, did not disclose their financial conflict of interest. In a recent paper in which SciPinion was also used, they did it (Garvey et al. 2023); non-disclosure of conflicts of interest has pointed out as a serious and constant problem in the journal *Regulatory Toxicology and Pharmacology* (Velicer et al. 2018), as well of ties with industry within its editorial board and an "apparent bias in favor of industries that are subject to governmental health and environmental regulations" (Axelson et al. 2003). Also regarding disclosure, J. K. A., co-author, selected as the topic leader of the panel, also a co-author of a more recent panel by SciPinion (Garvey et al. 2023), and responsible for "providing technical review, oversight, and input on each round's questions and format" (Anderson et al. 2022), did not disclose her work for Wolverine World Wide during a litigation about PFAS in Rockford, MI, a period when she also published on the company's website a post minimizing PFAS risks (Ellison 2018).

Another immediate problem is lack of transparency about important data. Transparency is important for it "(...) allows others to understand how the results of a scientific analysis could have been different if important judgements were made differently" (Elliott 2019, p.4). But, for example, in the paper it is said that during Round 1 "(...) panel was tasked with reviewing a summary document (Appendix A) and answering initial charge questions" (Anderson et al. 2022, p.3). However, there is no Summary Document in the Supplementary data (Anderson et al. 2022, Supp.) provided. This makes it impossible to evaluate affirmations such as "I appreciate the initial set of literature provided; however, [it] is biased towards U.S. situations and would not apply to Europe or to research" (Anderson et al. 2022, Supp., p.38) or, more importantly:

> I did not interpret this question as focusing on drinking water criteria. That actually would have made it much easier for me to answer! I would have limited the deffinition [sic.] to those PFAS that have actually been measured

> in drinking water. If this was the focus for al [sic.] questions, then the answers would also have been much easier. However, the background document did not focus on drinking water so that is why I did not interpret the question as having that narrow a focus (Anderson et al. 2022, Supp., p.8).

Question 2.1 (Anderson et al. 2022, Supp., p.48) also refers explicitly to a "draft Problem Formulation statement" that is not included in the Supplementary data, neither a link mentioned in Question 2.4 (Anderson et al. 2022, Supp., p.58) nor another Problem Formulation in Question 2.11 (Anderson et al. 2022, Supp., p.80). Again, this makes it impossible to evaluate properly all the answers provided. Finally, one could imagine whether some of the experts would accept the exercise if they had known that ACC was funding it, which, I highlight again, was not disclosed to them.

Because of these limitations, I will restrict my analysis to two theses that were included in SciPinion's press release about the paper, and also shared by ACC's website and the European FluoroCarbons Technical Committee's one: (i) "Persistence alone is not sufficient for grouping PFAS for the purposes of assessing human health risk", and (ii) "Most panelists agreed that it is inappropriate to assume equal toxicity/potency across the diverse class of PFAS".[4] As we saw, both theses refer to precautionary grouping approaches (p-sufficient and total organofluorine) that would regulate all or screen several PFAS, respectively. Because of that, I understand that those approaches conflict with ACC commercial's interests. The panel, then, allegedly concluded against those approaches. Now, by a textual analysis about these two theses and its reasons both in the paper and in the in the supplementary material, I will try to show that if some choices in the design of the panel, in textual analysis, and in the communication of the findings were different, (i) and (ii) would be more favorable to those grouping approaches. I reinforce again that I will not be presupposing that it was anyone's intention (explicit or implicit) to do so: I am focusing on their consequences.

4. Analysis

4.1. Persistence alone is not sufficient for grouping PFAS for the purposes of assessing human health risk?

There are at least three features in the design of the panel that affect the analyzed theses: the properties of consensus that the exercise could capture, the selection of participants, and the way questions were framed. By "properties of consensus" I refer to the panel's conditions which allowed expert's answers and interaction, and also to different ways of conceptualizing consensus; for example, is it a consensus when the majority of a group accepts a proposition or when a group agrees (implicitly or

explicitly) that a certain proposition stand as their position on a particular subject? (cf. Miller 2013) Regarding the first subject, it is important to note that experts only answered individual questions and commented each other answers with limited interaction. For example, they were not allowed to edit their answers and calls for clarification were ignored. In particular, expert four: "It would be great if we could edit our comments. I accidently hit the return key and could not edit my response" (Anderson et al. 2022, Supp., p.56); and expert six affirmed that: "I found it frustrating that comments typed into the box would disappear if they were not 'saved' before moving to the next question. That prevents any return for later editing if further thoughts occur as a result of reading more comments" (Anderson et al. 2022, Supp., p.57).

These conditions severely affect the quality of the consensus generated, but, more importantly, they allow one to conclude that there was no group deliberation about any issue. Therefore, any "consensus" about the panel is an inference made from the expert's answers. Hence, not only a different consensus about the p-sufficient and totalorganofluorine could have been detected if the panel was designed differently, but also an epistemically better one for thoughtful editions and deliberations could have occurred.

The selection of participants (their number, affiliations, and proportion of affiliations) can also affect the quality of the consensus. Contrast the 205 scientists from the Madrid Statement with the 11 of the present panel or the almost exact division between university affiliated experts (6) and consultant's company experts (5). It can also undermine how "independent" the panel really is: for example, the topic lead expert along two other colleagues of her current employer, GSI Environmental Inc., were authors of a 2020 paper also funded by the ACC (Goodrum et al. 2020). Notwithstanding, I will not address this issue further for I find other elements more relevant to the angle of analysis and the theoretical background of this paper.

Take, for example, the way questions were framed. In Question 11 each panel expert had to create a question that would be further answered by all experts in Round 3. Several questions were reformulated. Worryingly, the short question proposed by expert 9 "Is the P-sufficient approach a management option for PFAS that is *feasible*?" (Anderson et al. 2022, Supp., p.47; my italics) was reformulated to Question 2.9:

> What is the *scientific merit* of using environmental persistence as a means to group PFAS for regulations regarding manufacture, import and use? How could environmental persistence be defined? For any PFAS (based on the broadest OECD definition) that is not persistent itself and does not degrade into a persistent PFAS, would those then be excluded from further evaluation?" (Anderson et al. 2022, Supp., p.74; my italics).

Note, first, the change from "feasibility" to "scientific merit". I advance that this change allows one more space to criticize the P-sufficient approach, since it is the least

data-intensive approach and one can easily focus on the differences among individual PFAS. Now, discussions about its feasibility would take to discuss regulations by essential vs. non-essential uses of PFAS, which was endorsed by the already mentioned Madrid statement. As David Michaels (2020) would put it, "[. . .] [for industry] debating the science is much easier and more effective than debating the policy". Also, to see how changes in the paper were made in a way that favors data-intensive approaches, note how another question was reframed. Expert 5 originally wrote: "To what extent should an understanding of a Mode of Action (or Adverse Outcome Pathway or Toxicity Pathway) be developed to support reliance on in vitro findings related to toxic effects?" (Anderson et al. 2022, Supp., p.47), but in Q 2.14 we find:

> To what extent should an understanding of a Mode of Action (or Adverse Outcome Pathway or Toxicity Pathway) be developed to support reliance on in vitro findings related to toxic effects? Do you agree that information regarding a shared mode of action or converging adverse outcome pathway is the "*gold standard*" for informing grouping purposes? (Anderson et al. 2022, Supp., p.89; my italics).

Unsurprisingly, in the paper the addition of the most data-intensive grouping approach as the "gold standard" is highlighted: "These experts agreed that compound-specific MOA or adverse outcome pathway (AOP) information is 'the gold standard' critically necessary for grouping of PFAS for the purposes of human health risk assessment" (Anderson et al. 2022, p.6).

Second, I stress the inclusion of other questions outside the expert 9's original question scope and, specifically, the choice to adopt in this context the OECD broad definition of PFAS. In a previous question, experts were asked about this definition with the inclusion of specific information that may have produced an anchor bias against it:

> Round 1 responses from the panel were fairly mixed on a preference for a definition of PFAS. We are hoping to work towards consensus on this important issue. A table of example PFAS has been assembled and pertinent information gathered (see link below). Please refer to this when answering this question. *Note that the OECD 2021 definition forces many compounds used in medicine and agriculture, like Prozac and fipronil to be considered PFAS. Given this information*, which of the following definitions (listed in order of broadest definition to narrowest) is most applicable for defining PFAS that are of interest for drinking water exposures?" (Anderson et al. 2022, Supp., p.58; my italics)[5].

Third, differently than other questions that had multiple choice answers and facilitate analyses, this one only has each expert's discursive answer. It is hard to tell how the paper's conclusion that "[the p-sufficient] generally was not supported by

the rest of the panel" was derived. Such aggregating and crucial terms as "generally not supported" were not defined in the paper. All of this leaves room for a lot of textual manipulations and create several obstacles to analyses by other researchers of the panel's results. For example, analyzing the answers we have: three experts stated explicitly that the p-sufficient approach was not adequate (experts 1, 8, and 5); experts 4 and 11 argued against using persistence alone; expert 7 stated that persistence needs to be defined and calculated and expert 2 that criteria needs to be defined; expert 9 was explicitly in favor and expert 10 implicitly for connecting the p-sufficient approach with green chemistry principles and elaborating it; expert 3 expressed concerns about the difference of subject in this question from the "problem formulation" that, as I said before, it is not included in the paper; and expert 6 argued in favor of that approach for regulations regarding manufacture, import and use, but not for risk assessment (Anderson et al. 2022, Supp., p. 74-76). Apart from clearly negative (experts 1, 5 and 8) and positive answers (expert 9), the other answers can be interpreted in conflicting ways. For example, the answers from experts 2, 4, 6, 7 and 11 can be interpreted as negative answers or as qualified positive answers. In the first case, the majority would be against the p-sufficient approach, but, in the second, it would not be the case.

Also, there were no signs that important doubts such as "I do not believe it is the right parameter to use for grouping PFAS for risk assessment (*the main focus of this exercise?*)" (Anderson et al. 2022, Supp., p.74; my italics) or "Doesn't this consideration depart somewhat from the Problem Formulation as written? It specifies PFAS in drinking water and existing data. Presumably then, the world of PFAS is limited to those found or likely to be found in surface water" (Anderson et al. 2022, Supp., p.75) were addressed. The answers provided could have been different if that were the case. Furthermore, the strength of the theses about this subject in the paper could have been diminished if these doubts were mentioned, which did not happen: these statements and several others in different questions were not included.

Fifth, there is a misleading quotation in the paper with an objection to the p-sufficient approach. There it is said that:

> The application of "persistence" as a means of grouping PFAS seemed to be best supported when applied to a regulatory context of restricting manufacture and use. One panelist cautioned that even this application of the p-sufficient approach is highly uncertain and may result in the exclusion of "innocuous compounds whose economic importance may be fairly high" (Anderson et al. 2022, p.6).

The original quotation appears in the answers from Question 1.2 and not 2.9, and it has to do with another grouping approach:

> Managing the risk assumes that the risk has been assessed and the risk rises to the level that management is required. A screening risk assessment of

> on some worst-case scenario, and perhaps based on total fluorine might be feasible. However, such an approach might also be fraught with damning uncertainty. It is interesting to consider, and the management of risks could be accomplished on a class by class or group by group basis. given divergent differences in half-life and potency, I can imagine that management as a single class/group may exclude from use some fairly innocuous compounds whose economic importance may be fairly high (Anderson et al. 2022, Supp., p.13).

4.2. Most panelists agreed that it is inappropriate to assume equal toxicity/potency across the diverse class of PFAS?

The same pattern happened with expert 1's question, which was originally "Given the lack of toxicological data and targeted analytical methods for most PFAS, do you think a screening risk assessment could be conducted by assuming the total adsorbable/extractable organic fluorine concentration is equal to the concentration of a known toxic PFAS (e.g., PFOA)?" (Anderson et al. 2022, Supp., p.47) and was reformulated to:

> Given the lack of toxicological data and targeted analytical methods for most PFAS, when conducting an assessment of human health risk from PFAS in drinking water, do you think a screening level risk assessment could be conducted by assuming the total adsorbable/extractable organic fluorine concentration is equal to the concentration of a known toxic PFAS (e.g., PFOA)? What is the scientific merit of such an approach? If the results of TOF suggest a concentration greater than a PFOA based threshold, then what would be conclusion and next steps? If the results of TOF suggest a concentration less than a PFOA-based threshold, then what would be the conclusion and next steps? (Anderson et al. 2022, Supp., p.86).

Note here the inclusion of the criteria of scientific merit and not the feasibility of one or both, and several other questions than the original one. More importantly, here we have the results discriminated by a multiple-choice answer: six experts signaled "Yes, total adsorbable/extractable organic fluorine concentration can be used for screening level risk assessment" and five "No, total adsorbable/extractable organic fluorine concentration cannot be used for screening level risk assessment". It is not the case, therefore, that "Most panelists agreed that it is inappropriate to assume equal toxicity/potency across the diverse class of PFAS" as it was shared by the press release and in the abstract of the paper. It is important to stress that the press release did not inappropriately exaggerate the findings as happens in the case of scientific hype, but, instead, it stated a falsehood, a situation more closely related to cases of scientific misconduct (Intemann, 2022). Moreover, the paper's section in which the

results related to this question are discussed is named differently: "4.4.2. Lack of consensus regarding use of TOF as an initial screening step". The simple majority was in favor, but the choice done was to communicate it as a lack of consensus. If this result had been presented as "simple majority" in favor, which is also more accurate, the statement about it would be more positive. Either way, it is important to note how differently the result was communicated in the paper and in the press release, which shows the importance of taking both into account.

Be that as it may, it is implicitly implicated in this case that even a simple majority is not a consensus for those who analyzed the panel. If that is the case and, going back to our previous discussion about consensus, the design of the panel could not capture conceptualizations of consensus such as the group explicitly decides that a certain proposition represents their position, which kind of consensus is the panel trying to achieve? Nothing is said about this crucial notion to the exercise. One could imagine that they were working on the notion of 100% acceptance as consensus, but the only result that did get this value was not reported in the paper: all experts answered affirmatively to Question 2.16 "When considering the need to regulate PFAS manufacture, use, and import based on human health risks, should lifecycle considerations (risks during production, use and disposal, degradation) be taken into account?" (Anderson et al. 2022, Supp., p. 95). This is a really important agreement since, for example, a recent paper — with seven out of eight authors working for fluorine companies — argued in favor of excluding fluoropolymers of regulation focusing on data related only to use (Henry et al. 2018), as criticized subsequently (Lohmann et al. 2020). Not incorporating this result from the panel into the paper is surprising.

5. Conclusion

The above analysis shows how the panel experts' opinions (including those recognized for positions in conflict with part of fluorine industry regulatory approaches) were corrupted in a way that criticizes two precautionary grouping approaches. As I tried to demonstrate, if choices in the design of the panel, in textual analysis, and in the communication of the findings were made differently, the results about this urgent topic would clearly have been more favorable to those approaches. An immediate question that emerges after such a diagnostic is how to avoid such negative consequences of industry funding in research. Another is whether a scientist without conflicts of interests should accept the invitation to participate at a panel like the one analyzed here. Since both questions deserve a paper of their own to be properly addressed, I conclude with a brief reflection on them with the results presented in this paper in mind.

Concerning the first question, it is important to note that several approaches have

been proposed by authors who investigate the negative impact of industry-funded science. One can see them on a continuum based on how far we would departure from the actual system of industry-funded science: from minor changes such as full disclosure of industry funding and conflicts of interest, going to the creation of an international organization responsible for chemical safety test and registration (Volz & Elliott 2012), and finishing in only publicly funded science (Brown 2017).

It seems clear to me that this cases shows how disclosure is not a solution to the kind of negative impact I detailed, although it is necessary and important. First, here we had another case where some authors did not disclose their conflicts of interests, which continues to happen in several journals affiliated to important publishing companies. Second, even if they had disclosed it, it would not have prevented the problematic textual manipulations that were analyzed in this paper and that eventually tended to be in favor to the institution funding the exercise. Third, there are also important obstacles regarding how one should interpret a paper with information about conflicts of interests (cf. Elliott, 2008). Therefore, I find it plausible to say that this case study is sufficient to show how other, stronger measures are urgent in this context.

Regarding the second question, I think its answer can take a form of a moral dilemma with potential bad consequences on both sides: on one hand, if a scientist without conflicts of interest accepts to join such a panel and takes an active role trying to uncover industrial ploys, their opinions can be misleadingly reframed on the publication result and press releases; on the other hand, if a scientist without conflicts of interest does not accept it, it miss the chance of interacting critically with other experts and potentially influencing the result in a more reliable way. Although I do not think that either option is easy, I think that this papers helps illuminating the potential drawbacks of both.

A final lesson of the present paper is the need for scientists to verify the credentials and funders of institutions that invite them to such exercises before accepting it or not. As the case showed, industry (in this case, the ACC) may hire institutions such as SciPinion and not inform their funding to hide their ties. Therefore, it is important to keep in mind that apparent non-biased institutions may in fact be so.

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Notes

[1]@patrizutto's tweet on 19 jul 2022: "Scientific views on grouping #PFAS published in journal. @AmChemistry [ACC] funded the effort, which may prompt some to dismiss the conclusions. Yet, the authors are quite diverse & include scientists who've raised concerns about the chemicals". Available at: https://web.archive.org/web/20231010105022/https://twitter.com/patrizzuto/status/1549489724523421698?s=20.

[2]To make it more exact, PFAS such as PFOS and PFOA are long-chain PFAS, while their newer substitutes are short-chain. Long-chain PFAS are defined threefold: they refer to (i) perfluoroalkyl carboxylic acids (PFCAs) with seven fluorinated carbons or more (e.g., PFOA), (ii) perfluoroalkane sulfonates (PFSAs) with six fluorinated carbons or more (e.g., PFOS), and (iii) substances that degrade into perfluoroalkyl acids (PFAAS).

[3]The supplementary data analyzed can be found at: https://web.archive.org/web/20231103105256/https://ars.els-cdn.com/content/image/1-s2.0-S0273230022001131-mmc1.pdf

[4] SciPinion's press release can be found at: https://web.archive.org/web/20231103110417/https://www.pr.com/press-release/865635. The reference to ACC's is located at: https://web.archive.org/web/20231103110949/https://www.americanchemistry.com/chemistry-in-america/chemistries/fluorotechnology-per-and-polyfluoroalkyl-substances-pfas/pfas-grouping-an-emerging-scientific-consensus. Fluorocouncil's article can be found at: https://web.archive.org/web/20231103111245/https://www.fluorocarbons.org/news/most-experts-agreed-that-all-pfas-should-not-be-grouped-together/. There were two other theses shared by the press realease: (i) "most experts agreed that all PFAS should not be grouped together for risk assessment purposes" and (ii) "there is a lack of consistent interpretations of human health risk for PFAS and a lack of information for the vast majority of PFAS, which presents significant challenges for mixtures risk assessment". For the limitations presented, I do not analyze them here.

[5]See Expert 8 objection to this question: "These definitions simply define the very broad class of chemicals considered to be PFAS. None actually define the specific PFAS to be considered for the purposes of drinking water criteria. So whether a definition 'forces' compounds like Prozac is not important in choosing a specific definition for the class" (Anderson et al. 2022, Supp., p.59).

Acknowledgments

I have benefited from multiple audiences when writing different versions of this paper: my PhD advisor Pablo Mariconda, Fernanda Toito, Hugh Lacey, Luciana Zaterka, Renato Kinouchi, Yasmin Haddad, members of the Scientiae Studia Philosophical Association, and the public at the UFMG Graduate Congress in Philosophy, at the 17th International Congress on Logic, Methodology and Philosophy of Science and Technology, and at the International Postdoc Forum for the Philosophy of Science (specially, Corey Dethier and Alan Love). In particular, I would like to thank Kevin C. Elliott, whose careful mentorship and generous friendship has helped me in so many ways. I also would like to thank to the anonymous reviewers for their comments. Finally, this research would not be possible without the fellowships from The São Paulo Research Foundation (FAPESP), grant nº 2021/13983-9 and 2019/10200-3.