doi:10.2533/chimia.2024.594 Chimia 78 (2024) 594–600

Orchestrating Relevance –

Critique of a Questionable Trait of Modern Science Communication

Antonio Togni*

Abstract: This essay critically analyzes the widespread phenomenon of claiming relevance when reporting original research. Specific examples from an area of method development in organofluorine chemistry demonstrate that the pursuit of worthiness of the corresponding research is mainly justified by putting forward a broad general industrial context that could potentially benefit in form of applications. However, it is deliberately ignored that such applications are in the vast majority of cases highly improbable or objectively unrealistic. Notwithstanding that scientists are nowadays often explicitly forced to orchestrate relevance, be it by research-financing institutions and/or journals' reviewers, it is argued that this is, from the point of view of research ethics at least, problematic.

Keywords: Bullshit · Publication culture · Relevance · Science communication

Antonio Togni, born in the Italian part of Switzerland, studied chemistry and obtained his PhD at ETH Zürich in 1983. After a postdoctoral stay (1983–84) at the California Institute of Technology, he joined the Central Research Laboratories of Ciba-Geigy Ltd., where he worked as a research scientist and group leader in the field of asymmetric catalysis. He returned to ETH in 1992 as an Assistant Professor and became Full Professor of Organometallic Chemistry in 1999. His research interests are in the field of asymmetric catalysis, organometallic chemistry, and organofluorine chemistry. Antonio Togni has served as a member of the National Research Council with the Swiss National Science Foundation and was Vice-Rector for Doctoral Studies at ETH from 2016 to 2021. Since January 2021 he is a happy retiree who enjoys the reflection about science and temporarily continues teaching.

1. Introduction

I remember the late Jack Dunitz, an ever-inspiring teacher and colleague, once telling me that when reading articles from the current literature one can confidently skip the introduction, as it usually does not convey anything significant concerning the work being reported. While there is quite a lot of truth in such wisdom, it is worth taking a specific look to find out that what is being claimed mainly in the introductory section – and often even in the abstract – of many original articles appearing nowadays in the literature is the purported relevance of what is being reported.

Academic research should be intended to study fundamental aspects of science and aim at advancing and creating new knowledge. It should therefore address new and yet unexplored areas that may or may not become important in view of possible applications, though I would argue it should not be primarily meant as applied research. The issue of fundamental *vs* applied research and the pressure from politics and society on universities are important aspects that certainly contributed to sharpening the idea of relevance.[1] This is strongly connected to how the notion of scientific research and its purported aims developed in recent decades. While it is important to bear in mind that more general aspects have been critically analyzed before, it is beyond the scope of this essay to go into any details on concepts such as Mode 1 / Mode 2-knowledge-production (*i.e.* pure, basic, theoretical, disinterested research *vs* inter- and transdisciplinary, applied research),[2] or responsible research and innovation (RRI),[3] and the reader is referred to the cited literature. It is sufficient to say that the meaning of relevance of research must be understood within the same broad context as academic research itself is being critically scrutinized.

Academic research strongly relies on public financial support in the form of research grants, salaries for both professors and coworkers, laboratory infrastructure, consumables, travel to international meetings and the like. This has in recent times engendered an ever-stronger struggle for material resources, given that the number of scientists in academia has been steadily increasing. To realize this, it is sufficient to observe, for example, that the number of active PhD students at an institution like ETH Zürich has nearly doubled since the turn of the century. Another type of struggle concerns what I would call immaterial resources such as recognition in terms of citations and awards, publication in highly ranked journals, invitations as plenary speakers, career development, and so forth. The struggle for both material and immaterial resources might sadly give the impression that scientists in leading positions in academia spend a lot of their valuable time acquiring research money and working on their CV.[4] When it comes to submitting grant proposals and manuscripts for publication, it would appear that pointing out how important and relevant the own planned or just concluded work is, is a significant part of this struggle. In fact, it has been pointed out by the German philosopher Lara Huber

> "*[...] that claims of relevance have become acceptable (presentable) in the scientific publication practice [...]. A significant part of this is the fact that scientists, not only in the context of applications for research funding, but also in the reporting or publication of research results,* ***are coerced to specifically state the (epistemic) value of their research***."[5]

**Correspondence:* Prof. em. Dr. A. Togni, E-mail: atogni@ethz.ch
Department of Chemistry and Applied Biosciences Chemistry, ETH Zürich, CH-8093 Zürich

Thus, it is not surprising that claims of relevance – as an instrument to fight for primacy – fill up the introductory section of many papers appearing in the literature. As it will be shown below, it also occurs that very similar claims can be found in different papers describing very different and scientifically unrelated results, just because the very general context into which those works are embedded is allegedly the same.

It is legitimate to believe or at least hope that the own research is or may become highly significant and that it could lead to new important developments and/or commercial applications. However, it should be the general attitude of a scientist to keep claims about the relevance of the planned or submitted work within a reasonable and convincing frame. Unfortunately, it seems that in many cases one goes well beyond this reasonable frame while actively and consciously orchestrating relevance to an extent that objectively appears as skewed and inflated. I firmly believe that this nowadays rather ubiquitous, yet essentially neglected issue of science communication raises important ethical and philosophical questions that would deserve an in-depth and systematic scrutiny.

It is the aim of the present personal essay to first of all show the existence of this widespread phenomenon and to simply create awareness, specifically in the field of chemistry. This will be done by illustrating and critically discussing selected examples from the recent literature. A first motivation to writing an essay on this topic came just after my retirement, at a point in time when I started looking back to my past research activities and thinking a little more deeply about how research and the communication of it works and has developed since the time I was a student.[6] A further incentive came from the fact that I had been invited to participate in the 2022 Ethics Series events organized by the SCNAT (Swiss Academy of Sciences) and had been asked to deliver talks at various universities around Switzerland, which I also repeated on two occasions abroad. While accepting, I also spontaneously declared that I would only speak about 'Orchestrating Relevance', though I still had doubts whether or not this would be of any interest for audiences of mainly doctoral students and postdoctoral fellows. Partly to my surprise, however, the resonance turned out to be positive, though many students were rather worried about the perspective of being forced (*vide supra*) to claiming or making up relevance in their future work.

2. Setting the Stage: A 'Must-Be Relevance'

Before addressing relevance claims in the introduction of selected papers, it is very instructive to ascertain how a very prominent and unique act of communication related to science imparts new relevance to something being already relevant by its very nature: The research leading to a Nobel Prize. Indeed, the press release of 6 October 2021 of the Royal Swedish Academy of Science announcing the Nobel Prize in chemistry to Benjamin List and David MacMillan "*for the development of asymmetric organocatalysis*", as an example, states the following[7]:

> "*Building molecules is a difficult art. Benjamin List and David MacMillan are awarded the Nobel Prize in Chemistry 2021 for their development of a precise new tool for molecular construction: organocatalysis.* ***This has had a great impact on pharmaceutical research, and has made chemistry greener.*** *[...] Organic catalysts have a stable framework of carbon atoms, to which more active chemical groups can attach.* ***These often contain common elements such as oxygen, nitrogen, sulphur or phosphorus. This means that these catalysts are both environmentally friendly and cheap to produce. [...] Using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells. In this way, organocatalysts are bringing the greatest benefit to humankind.***"

Let us analyse a little closer some of the above statements, in particular those I put in boldface. *Organocatalysis has had a great impact on pharmaceutical research*. Imagine now an educated layperson who just got a treatment with a brand new drug healing them of a life-threatening disease. Such a person might be led to think they should be thankful to the new Nobel laureates for having invented a method that possibly led to the development of that drug. This is what that statement might indirectly imply, but that person is in fact being deceived by that statement! Now, what is pharmaceutical research and what does it entail? While there are no doubts that organocatalysis is being used by medicinal chemists in the pharmaceutical industry as a synthetic method, among several others, for the synthesis of new drug candidates, it is also clear that the whole of pharmaceutical research was, is, and will ever be much more than just applying a new synthetic methodology. Finding and commercializing new drugs implies a lot of biology and biomedicine, by *e.g.* identifying the over expression of a particular enzyme, which means characterizing a possible mechanism of a particular disease. This may then lead to designing and synthesizing possible new drugs, maybe even using organocatalysis. These will be then tested, first *in vitro*, subsequently in extended clinical trials, before being routinely administered to patients. In view of this, it is clear that stating the great impact of organocatalysis in pharmaceutical research corresponds to a very superficial exaggeration, to say the least. Similar considerations apply to declaring that organocatalysis *has made chemistry greener*. The present perfect tense 'has made' implies that chemistry is now in the condition of being greener than before, because of organocatalysis. If this were true, another educated layperson would be led to possibly and naively think that *e.g.* the overall CO_2 footprint of chemistry, or of the chemical industry for that matter, is now lower than it used to be before the invention of organocatalysis, which is obviously not the case. Again, another deception of the reader. Concerning the elemental composition of organocatalysts, saying that because of the elements O, N, S, and P these catalysts are *both environmentally friendly and cheap to produce* is so unqualified and simplistic, such that it is just non-credible. It also does not do any justice to *e.g.* other catalysts containing other elements that might be even more environmentally friendly and cheaper to produce than certain organocatalysts. Finally, stating that *using these reactions, researchers can now more efficiently construct anything from new pharmaceuticals to molecules that can capture light in solar cells* corresponds to yet another essentially untrue and totally misleading and exaggerated declaration. Note that I am by no means criticizing the importance of organocatalysis *per se*, even less so am I diminishing or belittling what colleagues List and MacMillan have contributed to chemical science. In fact, I think they deserved the recognition for their work with the award of the Nobel Prize. I am merely pointing out how flawed and untrustworthy the corresponding primary communication is.

3. Introducing the Philosopher's Concept of Bullshit

By way of summing up, the statements scrutinized above:

- Demonstrate a fundamental lack of concern with the truth (which is contrary to scientific attitude)
- Tend to fake things, though they are not plain lies
- Do not care whether what they describe corresponds to describing reality correctly
- Tend to deceive the reader, be it intentionally or not, into imagining or believing things far away from the truth

Taken in this sense, they are genuinely in line, in philosophical terms, with the definition of bullshit provided by the renowned philosopher Harry Frankfurt in his famous essay *On Bullshit*.[8] Some of the readers may now possibly associate the word 'bullshit' with a vulgar and mostly impolite connotation that one should not find in a respected scientific journal and could therefore feel irritated. However, it is important to note that since Frankfurt provided his first serious analysis of bullshitting as a cultural phenomenon, the word 'bullshit' became not only acceptable but made it to a now well-established term or concept that has been taken up by other philosophers as well.[9] Hence, dubbing the statements analyzed above as bullshit is actually nothing else than calling things by their appropriate name. As Frankfurt noted at the beginning of his essay:

> "*One of the most salient features of our culture is that there is so much bullshit. Everyone knows this. Each of us contributes his share. But we tend to take the situation for granted. Most people are rather confident of their ability to recognize bullshit and to avoid being taken in by it. So the phenomenon has not aroused much deliberate concern, nor attracted much sustained inquiry*."

Hence, one problem I see in connection with science communication as part of *our culture*, is that it is also affected by bullshit because many of us contribute to it. My second worry is that this state of affairs is taken for granted. Moreover, to the best of my knowledge, nobody has confronted the scientific community at large with this kind of worries, though there would be clearly the necessity to do so.

4. Orchestrating Relevance: Some Specific Examples from the Recent Literature

The expression 'orchestrating relevance' is my translation of the German term 'Relevanz-Inszenierung' that might have been used for the first time by Karin Knorr Cetina, a sociologist who carefully analyzed the production of knowledge in the fields of particle physics and biomedical research.[10]

Now, how is relevance being orchestrated in chemistry and why? The core of chemistry, *i.e.* synthesis, be it of complex organic molecules or solid-state materials, is an enabling science by its virtue of making innumerable products everybody uses in daily life. Think at how much chemistry is 'hidden', for example, in a device such as a mobile phone, an object many people would not spontaneously associate with the 'results' of chemistry. For many scientists in fields neighbouring chemistry, the making of all sorts of new materials is therefore a necessity left to chemists to take care of. Unfortunately, this may lead to think that chemistry is a servant science. When this kind of inherently dangerous thought is shared by chemists, it is not surprising that they will tend to see the relevance of their work primarily in *e.g.* specific technological or biomedical applications. No matter what new molecules or reactions they are reporting, they will point out implications of their work in areas they are not directly involved with. That the likelihood of such applications is in the vast majority of cases either vanishingly small or objectively nonexistent, is evidently not a sensible concern.

In order to illustrate and exemplify how relevance is orchestrated in publications recently appeared in the literature, I have chosen the relatively new but rather narrow topic of trifluoromethoxylation, *i.e.* the area of methods development in organofluorine chemistry concerned with the generation or installation of the substituent OCF_3, which I am familiar with. It turns out that this substituent can be generated either by trifluoromethylating an alcohol, or by introducing the intact OCF_3 group by the use of suited reagents, both approaches being milder than the direct fluorination of a preexistent methoxy group. Given that both trifluoromethyl and trifluoromethoxy are groups fundamentally different from methyl and methoxy, with respect to their properties and reactivity, it would seem that corresponding studies are sufficiently fundamental in character to justify research in the name of advancing chemical knowledge and devoid of the need of claiming possible applications in the first place.

For my critical analysis I have chosen four publications summarized in Figs. 1 to 4 in form of the crucial reaction being reported and key statements from the respective introduction, quoted verbatim, and I will focus on concepts or ideas highlighted there in red.

Since I don't want to exempt myself and the work of my research group from criticism, I will start by examining the work shown in Fig. 1[11] which was carried out in the frame of an international collaboration.

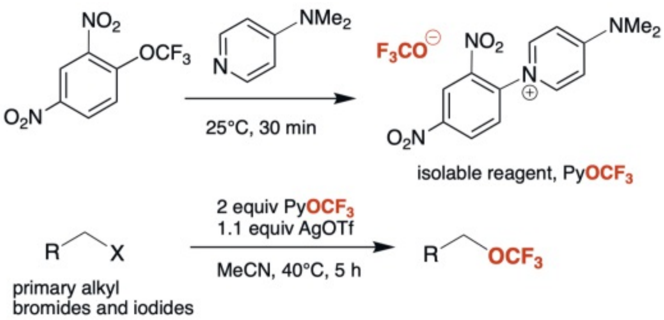
That the OCF_3 substituent is 1) *highly electronegative* and makes a compound 2) *more lipophilic* than a corresponding derivative lacking it, is in general true, though we did not measure or calculate the parameter logP for any of our new products.

"[…] The pronounced interest in this group [OCF_3] is due to its high lipophilicity (Hansch parameter: π = +1.04) relative to CF_3 and F, high electronegativity (Pauling's scale : 3.7), good metabolic stability and unique conformational properties. The interest in new methodologies is therefore rapidly increasing from an industrial perspective, as marketed OCF_3-containing pharmaceuticals and agrochemicals remain sparse. However, facile access to such compounds is often impeded by the lack of reagents capable of delivering this functional group under mild conditions at a late stage of a synthetic sequence."

Fig. 1. Generation of aliphatic trifluoromethyl ethers by the direct trifluoromethylation of alcohols with a hypervalent iodine reagent and statements from the introduction ref. [11].

Are these two of the reasons why there should be a *pronounced interest* in this group? To be honest, I don't know! That a trifluoromethyl ether will most likely resist metabolic decomposition, *i.e.* it displays 3) *good metabolic stability*, more so than an analogous non-fluorinated compound, is quite conceivable. However, we did not determine or quantify the *in vivo* stability of any of the new compounds reported. So, in fact it is not really legitimate to mention metabolic stability in the first place because we know nothing about it in terms of our own experimental results. It is also true that there are just a few commercialized trifluoromethyl ethers as biologically active derivatives, be it as drugs or crop-protecting agents. Is this sufficient to claim that there should therefore be an increasing interest in industry in new methodologies for the introduction of the OCF_3 group? Actually, I never heard or read any specific comment in this direction from colleagues in industry. Last but not least, it is claimed that there is a lack of reagents for the efficient transfer or generation of the OCF_3 group under mild conditions. This statement indeed conveys some truth and it clearly fulfills the purpose of quintessentially and implicitly claiming "*But we have one!*".

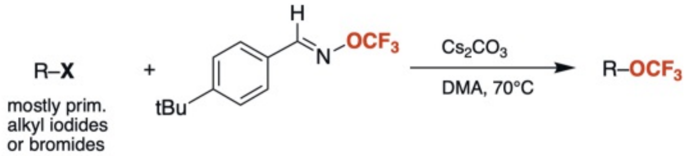
The introduction of the second chosen paper[12] (Fig. 2) conveys very similar statements as our own. Maybe it is stylistically formulated in a more straightforward and elegant manner. The key concepts are exactly the same, though the chemistry reported is totally different, *i.e.* fundamentally unrelated to the trifluoromethylation of alcohols. The only aspect common to both works is the OCF_3 group in the respective product molecules, and there was also no communication or exchange between the two author groups about their respective manuscripts. The reagent in Fig. 2 is actually one of the very few stable salts of the trifluoromethoxide ion known to date.[13] Thus, it can be used in nucleophilic substitution reactions to generate trifluoromethyl ethers from alkyl halides and represents the type of fundamental knowledge that could potentially even make an entry in future textbooks of organic chemistry. However, in the general context of claiming relevance, this does not appear to be of any importance. When saying *that considerable recent attention has been focused on developing practical and convenient reagents*, the reader is led to assume that these reagents' attributes should implicitly apply to those reported in this specific case too. However, does a reaction that needs two equivalents of the reagent and a slight excess of a silver salt and that is limited to primary alkyl iodides and bromides as starting materials satisfy the criteria of practicality and convenience, typically required in a *relevant* application setting? Most likely not and this is true also for the previous reaction, typically requiring a large excess of the starting alcohol in order to efficiently consume the relatively expensive reagent and obtain acceptable yields.



"The trifluoromethoxy group (OCF_3) has emerged as an important structural motif in scaffolds relevant to both agrochemical and pharmaceutical development. The introduction of an OCF_3 substituent has been shown to enhance the lipophilicity [Hansch parameter (π) = 1.04], bioavailability, and metabolic stability of biologically active molecules. As a result of the increasing importance of this functional group, considerable recent attention has been focused on developing practical and convenient reagents for introducing OCF_3 groups into organic molecules."

Fig. 2. Trifluoromethoxylation of primary alkyl bromides and iodides by using a stable trifluoromethoxide salt.[12]

The third example, shown in Fig. 3, reports a reaction similar to the second one in terms of substrates, *i.e.* alkyl bromides and iodides, but a totally different reagent, an aryl-*N*-trifluoromethoxy imine.[14] The ability of such a compound to deliver the OCF_3 anion is based on its C-H acidity and the generation of a stable nitrile byproduct. From a fundamental point of view, this qualifies in my opinion as an elegant solution because of a simple but effective molecular design. Again, the introduction relies on the same type of arguments in order to justify the work and claim its relevance (widespread applications, drugs and agrochemicals, lipophilicity, limited reagents *etc.*), however in a slightly different formulation, as compared to the previous two papers. A notable addition is the unqualified claim that trifluoromethoxylation chemistry represents *one of most important research hot spots* (!). While the enthusiasm of authors reporting successful new chemistry is un-

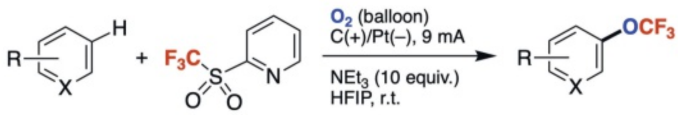


"A growing number of fluorine-containing organic compounds have widespread application in the fields of pharmaceuticals, pesticides and materials because of irreplaceable properties of fluoride. The incorporation of fluorine-containing groups has been an efficient strategy for the design of new drugs and agrochemical. In recent years, the late-stage and selective fluorination reaction of organic molecules has received significant attention, especially the trifluoromethoxylation reaction, which is one of the most important research hot-spots, as the trifluoromethoxy group's electron-withdrawing effects and high lipophilicity (Hansch parameter π = 1.04). However, the trifluoromethoxylation reaction remain limitations and challenges, such as limited trifluoromethoxylation reagents and instability of trifluoromethoxide anion, which impede its development and application."

Fig. 3. An *N*-trifluoromethoxy imine as a reagent for the nucleophilic trifluoromethoxylation of primary alkyl halides by nucleophilic substitution under basic conditions.[14]

derstandable, such a claim, though, goes well beyond the type of information a scientific paper should objectively and soberly provide.

The fourth chosen example[15] (Fig. 4) reports yet another fundamentally different reaction leading to products containing a trifluoromethoxy group. It relies, modernly, on electrochemistry, uses a trifluoromethyl sulfone as reagent together with molecular oxygen as the combined sources of the OCF_3 group, thus representing a very interesting innovation. The framing and embedding of the work in terms of claimed relevance is done again by using the very same general facts and purported general circumstances justifying OCF_3 chemistry. This paper appeared in early 2022, *i.e.* in a time where research possibly inspired by Covid 19 was still very much impellent. Thus, the claim concerning SARS-CoV-2 at the end of the introduction is best suited to underscore a possibly



"The trifluoromethoxy group (CF_3O) possesses a high lipophilicity parameter (Hansch parameter : π_R = 1.04) and specific electronic properties (Hammett constants : σ_p = 0.35, σ_m = 0.38). […] Meanwhile,the incorporation of trifluoromethoxy group into aromatics can modulate bioavailability, metabolic stability, and lipophilicity, while also introducing or retaining a key recognition element for biologic targets. As a result of these beneficial properties, trifluoromethoxylated aromatics have found increasing applications as pharmaceuticals. For example, Sonidegib (anticancer) and Pretomanid (antituberculosis) are the very recently FDA approved drugs in 2015 and 2019 respectively, and MI-09 is an excellent SARS-CoV-2 Mpro inhibitor with antiviral activity in a transgenic mouse model."

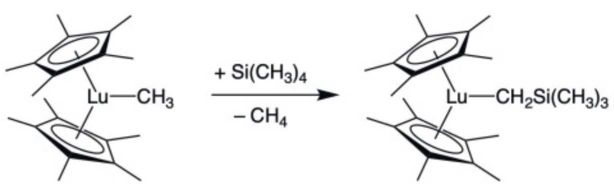
Fig. 4. *In situ* generation of the trifluoromethoxy group at an aromatic position from a trifluoromethyl sulfone and molecular oxygen under electrochemical conditions.[15]

far-reaching relevance even of a simple new synthetic reaction that has otherwise nothing whatsoever to do with the pandemic. However, naming at the right moment a context of such searing current importance may well be paradigmatic in view of underscoring relevance.

While having limited my presentation to four selected examples of papers in the area of trifluoromethoxylation chemistry claiming relevance all based on uncritically putting forward the very same arguments, it is clear that these do not represent an exception and further examples are provided in the references.[16]

One can now ask whether this is a phenomenon limited to a specific new area of synthetic chemistry, such as trifluoromethoxylation, or is it more general. This is most likely the case, though I did not perform any search and analysis in other areas of chemistry, or for that matter, of natural sciences, in which the tendency to overestimating the relevance of one's own work is most probably affecting the writing style of innumerable publications. Another important question is whether claiming relevance in the described way is the result of a progressive development and, if so, when did it start and why. I have to admit that I do not have a precise answer to such a rather complex problem. This would require a thorough analysis and comparison of the literature over a time span of several decades. What I can safely say is that the idea of claiming relevance has certainly not been planted in my mind when I was a PhD student or a postdoc, nor even during my years in industry. From my recollection I thus deduce that it certainly was not there thirty or forty years ago with nearly the same intensity and matter of course as it is nowadays. It rather took over later and it did so in a subtle, sneaky and almost perfidious manner, many succumbed to without even noticing.

Without being too effusive about the good old days, I take the reaction and corresponding first communication shown in Fig. 5 as a counter example, sort of my favourite role model, how science can be honestly and plainly communicated relinquishing any claim of purported or projected relevance. It concerns the fundamental discovery of the room-temperature smooth activation of C–H bonds in simple alkanes by organometallic lutetium complexes (by what later became known as the σ-bond metathesis mechanism), as reported by Patricia L. Watson in 1983.[17]

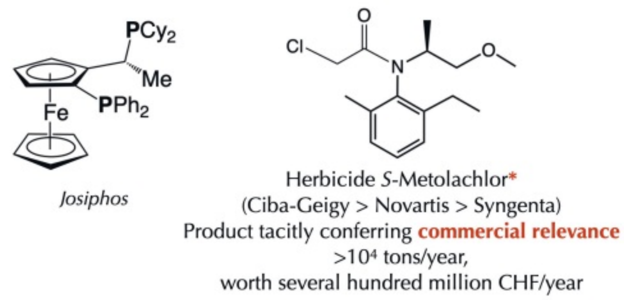


"**I report here that** lutetium-alkyl and -hydride derivatives can activate sp³ C-H bonds in both intra- and intermolecular reactions and even activate the sp³ bonds of $SiMe_4$. That these reactions occur under mild conditions with hydrocarbons of very low acidity is extraordinary for stable, isolatable complexes […]."

Fig. 5. The first ever observed activation of C–H bonds in alkanes by σ-bond metathesis reported in 1983 by P.L. Watson.[17]

In view of the objective significance and implications of this work, the formulation "*I report here that…*", by which the paper starts, immediately followed by the description of observations and results, is purely matter-of-fact and actually disarming. Given all developments which occurred in the area of C–H activation in the following forty years, one can say that this report is not only of high fundamental importance, but also that its relevance – not only *a posteriori* – is most likely higher than that of all trifluoromethoxylation papers taken together. In other words, the first ever reported C–H activation by σ-bond metathesis will be remembered for decades to come.[18] However, I am afraid that this will not be the case for most trifluoromethoxylation chemistry reported currently because they most likely represent a relatively modest temporary hype.

I cannot finish this brief exemplary overview without mentioning a second paper again stemming from my own research group, chronologically the first one dealing with the ferrocenyldiphosphine *Josiphos* and its uses in asymmetric catalysis.[19]



"It is not common that a chiral ligand for asymmetric catalysis equally performs in a variety of reactions. The general observation is that a certain chiral ligand can be successfully employed only for a specific combination of reaction type, catalyst, and substrate. […]"

Fig. 6. *Josiphos* and the major industrial product resulting from the application of one of its derivatives.[19]

Josiphos (Fig. 6) is the first representative of a class of chiral enantiopure ferrocenylphosphines that have been and still are widely used as ligands for a variety of transition-metal-catalyzed reactions, both in academia and industry. I mention this compound and its original report of 1994 also by way of rehabilitating myself after having accepted the sin of orchestrating relevance to an extent I should not have, as I did in the work of Fig. 1 discussed above. What the first few sentences in the introduction of the corresponding article convey is a very simple, objective consideration in the general context of ligand development of that time, underscoring the possible fundamental significance of that new compound and the at least partly surprising results obtained therewith. However, most appropriately, not a single word is spent pointing out a possible industrial relevance, though the development of a large-scale asymmetric hydrogenation process for the production of the enantioenriched herbicide *S*-Metolachlor by using a *Josiphos* ligand was already well underway, soon to be followed by commercialization in 1997.[20] It is important to realize that, no matter how lucrative the industrial application of new findings may be and, more broadly, how significant their societal impact may turn out to be, the epistemic value of such findings does not change significantly, as compared to the vast majority of cases where commercialization will never be attained. In more simple and crude terms, from a purely scientific perspective a commercial application does not go beyond the status of a detail because the real value of scientific knowledge is not primarily a financial matter.

5. Summary and Conclusion

A tentative generalization of how the orchestration of relevance may be first implemented and then perceived can be summarized by the following aspects, each one of them being more or less evident and characteristic depending on the specific cases:

- The own work is projected and embedded into a very broad general context, mostly of practical importance and typically in view of potential industrial applications. However, no actual real connection between the work being reported and the specific industrial domain being put forward is demonstrated to exist. This may also implicitly hint at the alleged role of chemistry understood and reduced to a servant science.
- The general context is easily and intuitively understandable to the non-specialist. The development of new drugs and/or new crop-protecting agents is a typical example. The synthesis of such new bioactive compounds could benefit from the work being reported, notwithstanding that in most cases such applications should objectively be considered as being highly improbable or unrealistic.
- The own work is presented as if it were a potential new solution to a supposedly important, though mostly ill-defined problem. This can ultimately be viewed as a way of selling a solution by concocting a corresponding problem in the first place, this going hand in hand with misrepresenting or ignoring facts, such as *e.g.* that the problem simply does not exist in the insinuated form.
- It also occurs that appreciations of and comparisons to competitors' work contribute in augmenting the pretended relevance, by explicitly pointing out differences in experimental parameters such as, for example, higher yields, a broader scope, the use of reagents or catalysts containing no metals, rather than of environmentally more benign ingredients instead.

Thus, orchestrating relevance is composed of a mixture of claiming or reiterating simple facts, putting forward a specific but not necessarily obvious context into which to embed one's own research, asserting possible opportunities or consequences, and highlighting the role of one's own work and its significance. It often implicitly appears to legitimize or even vindicate the corresponding research as if this would not have been carried out at all without that kind of relevance. Everyone in the academic setting of fundamental research should therefore ask him-/herself the question whether the inspiration to embark in a specific study derives from that alleged relevance, exclusively or at least to a significant extent. Personally, and as far as it concerns the entire body of my research, I can firmly declare that it is profoundly not the case.[21]

As it should be clear by now, orchestrating relevance is a widespread phenomenon in scientific communication. It often corresponds to an implicitly and mostly uncritically adopted habit. It becomes presentable, accepted, and taken for granted as if it were just a matter of 'innocent bullshitting', as often expected by journals and research funding agencies. In this sense it can be viewed as a sign of an opportunistic stance and conformism. The young generation of scientists is 'growing up' in a science system in which the orchestration of relevance has already become an almost obvious ingredient of science communication, one can no longer afford to ignore and must rather actively pursue. However, claims of relevance, because of their inherently unverifiable nature should be considered, in my opinion, at least as problematic, if not as plainly despicable from the point of view of ethics in science.[22] This is an issue deserving to be broadly discussed, in particular when educating the next generation of scientists.

Received: June 25, 2024

[1] For a unique contribution to the philosophical literature specifically addressing the issue of relevance, see: L. Huber, Relevanz, 'Über den Erkenntniswert wissenschaftlicher Forschung', Felix Meiner Verlag, Hamburg, **2020**. Huber focusses in her book on the various facets of relevance mainly in the areas of medical, in particular cancer-related, and climate research.

[2] a) M. Gibbons, C. Limoges, H. Nowotny, S. Schwartzman, P. Scott, M. Trow, 'The New Production of Knowledge', SAGE Publications, London, **1994**. b) H. Nowotny, P. Scott, M. Gibbons, 'Re-Thinking Science', Blackwell Publishers Ltd., Oxford, **2001**. Note that one of the authors of these two books, Helga Nowotny, was a professor for Social Studies of Science at ETH Zürich and from 2010 to 2013 President of the European Research Council. The distinction between Mode 1 (theoretical) and Mode 2 (commodified) production of knowledge has been more recently challenged: T. Knuuttila, *Sci. & Educ*. **2013**, *22*, 2443, https://doi.org/10.1007/s11191-012-9498-9. See also: J. Ziman, *Sci. Eng. Ethics* **2002**, *8*, 397, https://doi.org/10.1007/s11948-002-0060-z.

[3] See: a) M. Carrier, *Synthese* **2021**, *198*, 4749, https://doi.org/10.1007/s11229-019-02254-1. b) L. von Schomberg, V. Blok, *Synthese* **2021**, *198*, 4667, https://doi.org/10.1007/s11229-018-01950-8. See also: M. Carrier, A. Nordmann (Eds.), 'Science in the Context of Application', Boston Studies in the Philosophy of Science, Vol. 274, Springer, **2011**.

[4] Concerning the struggle for resources in connection with education, the philosopher Michael Hampe (ETH Zürich) has brought it to the point:
"[...] pushing capitalism out of the education systems again. Because education was originally concerned with knowledge and the development of persons, their moral and aesthetic consciousness. Today, education is preparation for the struggle for resources. If education is understood in this way, the education system gives rise to good and bad overwhelmers, but no longer to morally and aesthetically reflected, creative people striving for knowledge."
(A. Togni, translation of the original text in German)
M. Hampe, Interview with *Republik*, 4 January 2019, on the occasion of the publication of the book 'Die dritte Aufklärung', Nicolai Publishing & Intelligence, Berlin, **2018**. Concerning academic capitalism, see *e.g.*: R. Münch, 'Academic Capitalism. Universities in the Global Struggle for Excellence', Routledge, **2014**. For an analysis of how the CV of scientists has evolved as an expression of the immaterial struggle for resources, see: B. Macfarlane, *Studies in Higher Education* **2020**, *45*, 796, https://doi.org/10.1080/03075079.2018.1554638. See also: B. Macfarlane, *Oxford Review of Education*, **2024**, *50*, 468, https://doi.org/10.1080/03054985.2023.2243814.

[5] See ref. [1], p. 127, A. Togni translation of the original text in German:
"[…] dass Relevanzbehauptungen in der wissenschaftlichen Publikationspraxis […] hoffähig geworden sind. Einen massgeblichen Anteil hieran hat der Umstand, dass Wissenschaftlerinnen und Wissenschaftler, nicht nur im Rahmen von Anträgen um Forschungsmittel, sondern auch bei der Berichterstattung oder der Publikation von Forschungsergebnissen, genötigt werden, den Erkenntniswert ihrer Forschung jeweils spezifisch auszuweisen."

[6] I had first touched upon 'Orchestrating Relevance' in the frame of my Farewell Lecture at ETH, I delivered on 28 October **2021** (https://video.ethz.ch/speakers/lecture/0ed32c3d-c142-422e-bcea-312917532ef7.html).

[7] https://www.nobelprize.org/uploads/2021/10/press-chemistryprize2021.pdf

[8] H.G. Frankfurt, On Bullshit, Princeton University Press, **2005**. The same text had been previously published a) first as an essay in 1986: H.G. Frankfurt, On Bullshit, Raritan **1986**, VI, 81, https://raritanquarterly.rutgers.edu/issue-index/all-articles/560-on-bullshit, and b) in a collection of essays: H.G. Frankfurt, 'The importance of what we care about, Philosophical essays', Cambridge University Press, **1988**, 117-133.

[9] The analysis of the widespread cultural phenomenon Bullshit, as inspired by Harry Frankfurt, has led to further significant publications. See *e.g.*: a) G.A. Cohen, 'Deeper into Bullshit', In S. Buss, L. Overton (Eds.), 'Contours of agency: Essay on themes from Harry Frankfurt', MIT Press, **2002**, pp. 321-339. b) A. Stokke, D. Fallis, 'Bullshitting, Lying, and Indifference toward Truth', Ergo **2017**, 4, 277, https://doi.org/10.3998/ergo.12405314.0004.010. c) V. Moberger, *THEORIA* **2020**, *86*, 595, https://doi.org/10.1111/theo.12271. d) G.L. Hardcastle, G.A. Reisch (Eds.), 'Bullshit and Philosophy', Open Court, Chicago, **2006**.

[10] Karin Knorr Cetina, 'The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science', Pergamon, Oxford, **1981**; the 'Management of relevance' is treated on pp. 110-112. (German version: 'Die Fabrikation von Erkenntnis. Zur Anthropologie der Naturwissenschaften, Erweiterte Neuauflage', Suhrkamp, **2002**, 'Relevanz-Inszenierung' is mentioned on pp. 207-208).

[11] J. Kalim, T. Duhail, E. Pietrasiak, E. Anselmi, E. Magnier, A. Togni, *Chem. Eur. J.* **2021**, *27*, 2638, https://doi.org/10.1002/chem.202005104.

[12] G. Duran-Camacho, D.M. Ferguson, J.W. Kampf, D.C. Bland, M.S. Sanford, *Org. Lett.* **2021**, *23*, 5138, https://doi.org/10.1021/acs.orglett.1c01664.

[13] For a thorough characterization of the reagent, see: C. Bonnefoy, E. Chefdeville, A. Panosian, G. Hanquet, F.R. Leroux, F. Toulgat, T. Billard, *Chem. Eur. J.* **2021**, *27*, 15986, https://doi.org/10.1002/chem.202102809.

[14] Y. Li, Y. Yang, J. Xin, P. Tang, *Nat. Commun*. **2020**, *11*: 755, https://doi.org/10.1038/s41467-020-14598-1.

[15] Y. Ouyang , X.-H. Xu, F.-L. Qing, *Angew. Chem. Int. Ed*. **2022**, *61*, e202114048, https://doi.org/10.1002/anie.202114048.
[16] For further examples of articles reporting trifluoromethoxylation reaction conveying similar relevance claims as discussed, see: a) P. Golz, K. Shakeri, L. Maas, M. Balizs, A. Pérez-Bitrián, H.D. Kemmler, M. Kleoff, P. Vossnacker, M. Christmann, S. Riedel, *Chem. Eur. J*. **2024**, *30*, e202400861, https:// doi.org/10.1002/chem.202400861. b) D. Chen, Y. Luo, L. Lu, Q. Shen, *Organometallics* **2024**, *43*, in print, https://doi.org/10.1021/acs.organomet.4c00073. c) L. M. Maas, C. Fasting, P. Vossnacker, N. Limberg, P. Golz, C. Müller, S. Riedel, M.N. Hopkinson, *Angew. Chem. Int. Ed*. **2024**, *63*, e202317770, https://doi.org/10.1002/anie.202317770. d) W.-J. Yuan, C.-L. Tong, X.-H. Xu, F.-L. Qing, *J. Org. Chem.* **2023**, *88*, 4434, https://doi.org/10.1021/acs.joc.2c03031. e) J. Xin, X. Deng, P. Tang, *Org. Lett*. **2022**, *24*, 881, https://doi.org/10.1021/acs.orglett.1c04226. f) W. Zhang, J. Chen, J.-H. Lin, J.-C. Xiao, Y.-C. Gu, *iScience*, **2018**, *5*, 110, https://doi.org/10.1016/j.isci.2018.07.004. g) M. Zhou, C. Ni, Y. Zeng, J. Hu, *J. Am. Chem. Soc*. **2018**, *140*, 6801, https://doi.org/10.1021/jacs.8b04000. h) H. Kondo, M. Maeno, K. Hirano, N. Shibata, *Chem. Commun*. **2018**, *54*, 5522, https://doi.org/10.1039/C8CC03131B.
[17] P. L. Watson, *J. Chem. Soc., Chem. Commun*. **1983**, *276*, https://doi.org/10.1039/C39830000276.
[18] For a homage, see: D.J. Mindiola, 'Pioneers and Influencers in Organometallic Chemistry: Dr. Patricia Watson and the Molecular Dance of M–C and M–H Bonds', *Organometallics* **2020**, *39*, 1135, https://doi.org/10.1021/acs.organomet.0c00225.
[19] A. Togni, C. Breutel, A. Schnyder, F. Spindler, H. Landert, A. Tijani, *J. Am. Chem. Soc*. **1994**, *116*, 4062, https://doi.org/10.1021/ja00088a047.
[20] For an account on the development of the herbicide *S*-Metolachlor, see: H.-U. Blaser, F. Spindler, *Top. Catal*. **1997**, *4*, 275, https://doi.org/10.1023/A:1019164928084.
[21] For a personal account, see: A. Togni, *CHIMIA* **2023**, *77*, 468, https://doi.org/10.2533/chimia.2023.468.
[22] "Impact sensationalism" in research proposals has been analyzed in the perspective of research integrity recently, see e.g.: J. Chubb, R. Watermeyer, *Studies in Higher Education*, **2017**, *42*, 2360, https://doi.org/10.1080/03075079.2016.1144182.