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Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

Empfohlene Zitierung / Suggested Citation:
Gaillard, S., Mody, C., & Halffman, W. (2023). Overpromising in science and technology: An evaluative conceptualization. *TATuP - Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis / Journal for Technology Assessment in Theory and Practice*, *32*(3), 60-65. https://doi.org/10.14512/tatup.32.3.60

TATuP Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis
Journal for Technology Assessment in Theory and Practice

oekom science

RESEARCH ARTICLE

Overpromising in science and technology: An evaluative conceptualization

Stefan Gaillard*,[1], Cyrus Mody[2], Willem Halffman[1]

Abstract • This research article examines overpromising in scientific discourse that may raise unrealistic expectations in order to gain trust and funding. Drawing on signaling theory, philosophy of promising, and science communication research, a conceptualization of overpromising is presented. This conceptualization facilitates the evaluation of promises in science and technology and highlights the importance of the knowledge context. Further research is needed to explore the broader dimensions and motivations for overpromising.

Overpromising in Wissenschaft und Technik: Eine evaluative Konzeptualisierung

Zusammenfassung • *In diesem Forschungsartikel werden übertriebene Versprechungen im wissenschaftlichen Diskurs untersucht, die überzogene Erwartungen wecken können, um Vertrauen und finanzielle Unterstützung zu erhalten. Basierend auf der Signaling-Theorie, der Philosophie des Versprechens und der Forschung zur Wissenschaftskommunikation wird eine Konzeptualisierung des Overpromising vorgestellt. Diese Konzeptualisierung erleichtert die Bewertung von Versprechen in Wissenschaft und Technik und hebt die Bedeutung des Wissenskontexts hervor. Weitere Forschung ist erforderlich, um die breiteren Dimensionen und Motivationen für übertriebene Versprechungen zu untersuchen.*

Keywords • *conceptualization, evaluation, overpromising, promises, signaling*

This article is part of the Special topic "Technology hype: Dealing with bold expectations and overpromising" *edited by J. Bareis, M. Roßmann and F. Bordignon. https://doi.org/10.14512/tatup.32.3.10*

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https://doi.org/10.14512/tatup.32.3.60
Received: 31. 05. 2023; revised version accepted: 20. 10. 2023;
published online: 13. 12. 2023 (peer review)

Introduction

Overpromising of potential breakthroughs or social benefits is a regular feature of scientific discourse (Rip 2006): In order to attract research funding, promote research projects, or attract public attention, researchers make inflated or even untenable claims (Eisler 2012). Particularly in disciplines like nanoscience, dependent on their supposed future potential for funding and appeal, such promises are prevalent (Mody 2006).

Promises are assurances which may lead to expectations and agreements, and can therefore be used as signals to solicit trust or other resources. Promises can take little time and effort for the promiser, but if there is information asymmetry, assessing the promise will take more time and effort for the promisee. Together, these three characteristics can incentivize overpromising in science and technology; scientists who overpromise can gain short-term benefits with easily expressed promises, while it is difficult for promisees to assess promises at the frontier of knowledge. At the same time, promisees such as colleagues, funders, and policymakers, would benefit from improved overpromise detection. This article offers a conceptualization to assist in a more time-efficient, critical investigation and interrogation of overpromises, specifically for future-oriented promises (under conditions of information asymmetry) assuring breakthroughs or social benefits. Although knowing the characteristics of the promisers would further facilitate this investigation and interrogation, this is left for future study.

A broken promise is not a necessary condition for overpromising.

Our investigation draws on signaling theory (Gambetta 2011), philosophy of promising (Sheinman 2011 a), and science studies research on scientific communication. To clarify overpromising and its proposed assessment, we include examples from nanobiology, taken from grant applications, reports, popular science books, and patents. We conduct a conceptual analysis of over-

promising to distinguish overpromises from other types of promises and subsequently outline the context involved in assessing the plausibility of scientific promises.

Promising in science and technology

When a person, such as a scientist, makes a promise about the future, they either 1) assure (Parkhill 2008; Scanlon 1990) that they (will) do something, or 2) assure that a specific outcome will occur. Unlike philosophers such as Thomas Scanlon (1990), we do not consider it necessary for the assurance to be made purposefully for it to be a promise. This assurance distinguishes promises from other predictions like forecasts, which only describe potential actions or outcomes.

For 1), the promiser self-imposes an obligation to keep their promise (Driver 2011; Rand 1984, p. 136). For 2), the promiser stakes their reputation on the actual occurrence of the events they have promised. They therefore have a responsibility to refrain from irrational promises which 1) they cannot fulfil, thus failing their obligation, or 2) will not come true, thus breaking the confidence of their promisee (Parkhill 2008; Rand 1984, p. 136). As such promises can harm their scientific endeavors in the long run, scientists have an occupational responsibility to refrain from such promises – just like they have an epistemic responsibility to know and check their sources or methodology. Like research integrity issues, where some cases may be clearly fraudulent and others debatable, some promises may be evidently irresponsible, while others merely questionable.

We can distinguish between "individual acts of promising, practices of promising, and the relation between them" (Sheinman 2011 b, p. 3). Promises do not occur in isolation, but rather are part of and influenced by, for example, cultural traditions, ongoing debates, and professional norms. Depending on the practice of promising they are part of, individual acts of promising can lead to different expectations or agreements and, by extension, obligations.

Practices of promising

Scientists engage in various promising practices, including those customary to their medium of communication. Promises made in books will differ from promises made in articles and, similarly, promises made in popular science books will differ from promises made in textbooks. Promisers, in their writing, must attend "to the stylistic conventions and preferences of the editor and audience", as Charles Bazerman (1988, p. 202) already established for how authors express themselves in experimental articles. Prior research documents how scientists adapt accounts of their actions and beliefs for different social situations (Gilbert and Mulkay 1984). These varying accounts are influenced by the intended audience: "[W]hen scientists write experimental papers, they make their results meaningful by linking them to accounts of social action and collective belief" (Gilbert and Mulkay 1981, p. 270).

These conventions shape the perception and consequences of promises. For example, scientific and technological promises made in popular science books engender beliefs on the part of their audience: When a scientist states that "[n]anoshells can be configured to scatter light as well as absorb it. This scattering can be used to create an image of where the nanoshells congregate. A possible future treatment could have the cancer patient visit the doctor periodically to be injected with special nanoshells coated with antibodies that would search for various types of cancer. Then electronic scanning would find the nanoshell congregations and allow pinpoint targeting of the laser – which would then cook the tumors – all in one afternoon" and subsequently assures that "[h]uman trials for this technique will begin within the next few years" (Foster 2006, p. 267), this may lead cancer patients to believe that human trials will commence during their lifetime.

Promises and agreements

Promises occurring between a promiser and a promisee lead to implicit or explicit agreements; through the act of promising, "the promiser commits to the promisee to do what's promised" (Sheinman 2011 b, p. 3). The promiser and the promisee come to an agreement, often with the promiser committing to a course of action.

When a group of researchers promises to a funder that they will "share entire datasets using the open microscopy environment" (Bordignon et al. 2023), and the funder consequently provides funding, the two come to an agreement. These types of agreement are often explicated in legal documents. For example, in Horizon Europe grants, beneficiaries and the funding agency sign a contract outlining the general terms and conditions, as well as the rights and obligations of both parties (Danish Ministry of Higher Education and Science 2023).

One could argue that in grant applications, all parties understand that not all promises will be fulfilled due to the inherent uncertainty of scientific research and technological development, and thus that the implicit agreement differs from what they would expect if they took the promise literally (White 2017). Indeed, for many grants, funders only check whether promises mentioned in tandem with deliverables and milestones are fulfilled. As one grant applicant put it:

> *"When writing a grant it is important to find a good balance between what you promise to do in the general parts of the grant and what you truly deliver […]. In general, when it comes to scientific work we don't tend to overpromise much and activities are usually directly translated into deliverables. When it comes to stakeholder engagement, dissemination, communication and exploitation of results however this translation is often less direct and therefore less balanced; in general we tend to overpromise in impact sections and purposefully set out to not capture all those promises in concrete deliverables to allow as much room to deviate throughout the project"* (Gaillard's personal correspondence by e-mail, 03. 04. 2023, anonymized).

https://doi.org/10.14512/tatup.32.3.60

Rules of the game

Even without leading to (formal) agreements, promises in grant applications can create expectations, for example among inexperienced researchers unfamiliar with the rules of the game. The lack of codified conventions, coupled with the promisee's ignorance of these conventions, hinders proper understanding of the signaled intentions. Similarly, statements which are not expressed as promises might still be interpreted as promises due to the context in which they are made. Scientists may hedge their statements about the future or their future actions by presenting them as mere predictions, but do so in contexts where the audience might interpret them as promises, leading them to either expect the scientists to conduct certain research and deliver particular outcomes or expect certain developments to occur. Promisers therefore need to carefully take into consideration their (potential) audiences.

Which expectations, beliefs or agreements follow from the cultural, societal or occupational context influences what the promise exactly entails, and thus whether the promise is an overpromise or not. If the adequate interpretation of promises is practice-specific, misinterpretation across practices may be looming. For all these reasons, we can question the rules of the game that give rise to overpromising.

Overpromising in science and technology

Overpromising in science and technology refers to scientists promising more than is rational within their context of knowledge – which means, the total sum of their knowledge. Given our current state of knowledge, some promises can be known to be impossible, for example, promises which violate the law of identity. In other cases, there might be an ongoing debate about the current state of knowledge, leading to conflicting views on whether a promise is questionable or not. This happened when futurist and engineer Eric Drexler and chemist Richard Smalley debated Drexler's promises concerning molecular assemblers. In the 1980s, Drexler made promises regarding scientific and technological developments such as "molecular assemblers will bring a revolution without parallel since the development of ribosomes, the primitive assemblers in the cell" (Drexler 1986, p. 21). According to Smalley, fundamental, unavoidable and thus insurmountable problems would arise when trying to build these molecular assemblers (Smalley 2001), meaning Drexler's promises would be overpromises. As a final category, there are promises that do not contradict established knowledge, yet are inherently uncertain due to the exploratory nature of scientific research. However, even under uncertainty, we can distinguish promises from overpromises by whether they consider the current context of knowledge. It is precisely in these cases where the determination of whether they are overpromises becomes most challenging and where conceptual clarification is most essential.

Overpromising and broken promises

Because overpromising entails making promises without taking into consideration the context of knowledge, overpromises are often broken. However, it does not follow that broken promises are necessarily due to overpromising or that a fulfilled promise was not an overpromise when it was made. Although one might intuitively look to broken promises for indications of overpromising, this strategy would limit the investigation of overpromises to retroactive analysis and runs the risk of unjustly equating overpromises with broken promises. Consider the following two cases. First, scientists who had made promises to their funders about conducting research in exchange for funding in the period just prior to the COVID-19 pandemic. During the pandemic, it became clear that they would not be able to sufficiently access their laboratories, making their promised deadlines impossible (Stoye 2020). Yet their original promises were not overpromises: Their promises were possible at the time they were made – they could not have foreseen that a pandemic would subvert their deadlines.

Second, the American privately held corporation Theranos. The company's owner and its president assured potential investors that Theranos would develop devices using finger-prick blood samples for a wide range of laboratory tests (Levine 2018). Early on, these promises closely resembled academic overpromises – the owner told investors that the company would do the research needed to meet the promised benchmarks for scaled-up production and improved reliability and sensitivity, similarly to the promises made in grant applications. However, the founder of Theranos made these assurances even though there was no indication the company was able to develop these devices. She maintained this unfulfilled promise for fifteen years, until the company was legally dissolved for having lied to investors.

Context of knowledge

These cases illustrate that whether a promise was fulfilled or not is not the determinant of whether a promise is an overpromise, but rather whether the promisers take into consideration the context of knowledge when making a promise. In both cases, the promise was broken, but in the first case the promisers took into account all the knowledge available to them; in the second, they did not. When they made their promise, the scientists in the first case could not have expected that the COVID-19 pandemic would occur and disrupt their ability to meet deadlines (Stoye 2020). Therefore, when they made their promise, it was rational: Under normal circumstances they would have had lab access, and subsequently would have been able to meet deadlines and fulfill their promises. In the second case, the Theranos company owner and company president actively evaded considering the knowledge available to them.

A broken promise is therefore not a necessary condition for overpromising. The fulfillment of a promise cannot be the sole measure to classify a promise as an overpromise, much like a car crash does not automatically indicate reckless driving. Both cases could be influenced by many (unforeseen) factors. But

 https://doi.org/10.14512/tatup.32.3.60

just as a car crash can lead to inquiries about reckless driving, an unfulfilled promise can instigate investigation into potential overpromising.

Overpromises and deceptive promises

Theranos not only overpromised, it also made deceptive promises: It deliberately exaggerated assurances and misled funders in order to bring in investments. The promise was made both without taking into account the knowledge context, i.e., an overpromise, and without the aim of fulfilling it, i.e., a deceptive promise (Markovits 2011, p. 298). Although actors make promises with a specific aim, overpromises can arise for a number of reasons, such as sloppiness, routines learned from others and repeated uncritically, or overenthusiasm. When an overpromise is made with the aim to fulfill it, the promiser may fail to take the knowledge context into account, neglecting their epistemic and moral responsibility, but they are not purposefully deceiving the promisee (Markovits 2011, p. 298).

Scientific promises which are both deceptive and overpromising are sometimes thought of as 'strategic promises', made with the purpose of obtaining funding or creating support. In Theranos' situation, promises were strategically made to secure funding. Whether impossible promises made in grant applications without the aim of fulfilling them also fit this category depends on whether all the involved parties understand that the promises made are empty promises or not – i.e., it depends on the rules of the game and how they are understood by the audience.

Evaluating promises

Investigating whether a promise can be fulfilled involves an evaluation of the plausibility of underlying inferences about the future, a common practice for assessing a variety of claims about the future (Fischer and Dannenberg 2021) and for distinguishing predictions worthy of consideration from those that are not. This is relatively straightforward for promises which the evaluator knows to be impossible based on their current knowledge. However, for promises made under conditions of information asymmetry, a systematic evaluation of future claims is required. This evaluation begins by determining which aspect(s) of an inference need to be clarified for the evaluator to enable a judgement (Fischer and Dannenberg 2021, pp. 8–9). To this end, several analytic tools are already available from argument analysis (Epstein 2013) and ethics of emerging technologies (Lucivero et al. 2011), but these are not specifically tailored to show how to question future-oriented scientific promises *based on the context of knowledge*.

Therefore, we propose here to question future-oriented promises in science and technology by identifying and evaluating dimensions of the context of knowledge, building on some of the cognitive dimensions identified by sociologist Ann Mische. Although Mische (2009) uses these dimensions descriptively, to analyze without judgement how futures are conceptualized, her theory serves as a useful basis for the assessment of promises. We look at four dimensions of the context of knowledge, namely clarity, level of certainty, degree of control, and connectivity. Although we focus on promises in this article and not promisers, it is important to note that for many dimensions, knowing who makes the promise is often useful for determining the plausibility of the promise in that regard, because different actors have, for example, differing degrees of control or track records.

Clarity

Scientific promises are conveyed with differing clarity. Some are highly specific with regards to when the promise will be fulfilled, such as the promise that "[n]umerous newly designed, advanced materials and manufacturing processes will be built by 2015 using control at the nanoscale level" (Foster 2006, p. 229). Other promises are vaguer with regards to when the promise will be fulfilled: "In the business and investing world, the changes nanotechnology will bring in the next few decades will change the way people consume things" (Booker and Boysen 2011, p. 2). Many scientific promises lack even this general timeline of when the promise will be fulfilled, like the following example: "With the study of nano-size particles, devices, and composites, we will find ways to make stronger materials, detect diseases in the bloodstream, build extremely tiny machines, generate light and energy, and purify water" (Booker and Boysen 2011, p. 2). Note that the promise itself does not provide much clarity either. For example, it is unclear which type of strength is meant (tensile, compressive or shear), or which diseases will be detected.

Decisiveness

Future-oriented promises are conveyed as assurances. Scientists promise that something *will* happen or that they *will* do something. If they do not want to convey such decisiveness, they can make other types of predictions instead, such as expectations or forecasts (De Wilde 2000, pp. 15–17). Previous work on scientific communication has documented the tendency of scientists in multiple fields to make more decisive statements inversely correlated with how scientific the outlet is (Bucchi 1998); the less scientific the outlet, the more decisive the statements.

Besides intended audience, various other genre features will influence the decisiveness of scientific promises, such as word limits. If a grant applicant has to specify how 100,000 dollars will be spent, a 1,000-word limit will allow for less nuanced promises than a 10,000-word one.[1]

Promises may also lose nuance over time, or statements about the future might start out as other types of predictions, but evolve to become promises, due to an increase in the conveyed decisiveness. In the 2007 popular science book *Nanotechnology 101*, repeated reference is made to a prediction by the National Science Foundation. The first reference explicitly states it as a prediction: "The National Science Foundation predicts that the global marketplace for goods and services using nanotechnol-

1 We thank Diego Gambetta for this example.

https://doi.org/10.14512/tatup.32.3.60

ogies will be worth a trillion dollars by 2015" (Mongillo 2007, p. xvii). The second reference no longer states it as a prediction, but still does not convey an assurance, instead using the hedge word *could*: "By 2015, nanotechnology could be a $ 1 trillion industry" (Mongillo 2007, p. 3). However, almost immediately afterwards, this statement transforms into a promise, assuring the layman reader that "[a]s was stated earlier, the global marketplace for goods and services using nanotechnologies *will* grow to $ 1 trillion by 2015" (Mongillo 2007, p. 4, own emphasis).

Degree of control

Promisers may also fail to account for factors that affect the degree to which promises are achievable, overestimating their own limited capacity to control future events. If scientists overstate their degree of control, promisees and other interested parties such as funders might further inquire into how the promiser assumes to have control and how they would act if it appears they do not.

In one grant application, researchers stated: "Through continual conversation with nanobiologists we will convince the community that what we have to offer is not just helpful, but necessary for the field to advance" (Bordignon et al. 2023). The promisers did not consider the degree to which others will comply; they made a promise that depends on the actions and beliefs of nanobiologists, over which they have limited control. They cannot guarantee the funders that nanobiologists will become convinced; that decision ultimately is up to the nanobiologists themselves. Additionally, the promisers cannot accurately predict how persuasive they will be in convincing enough individuals within the community to support their proposal.

Relatedly, the fulfillment of scientific promises about potential benefits is often conditional upon enthusiasm about the technology or intervention needed to bring about these supposed advantages. Many promises related to the possible benefits of these technologies or interventions can only be realized if the technology or intervention is embraced and implemented, over which the promiser has little to no control. Whether fulfilment of the promise is considered plausible then hinges on whether the assessor considers it plausible that the circumstances (will) favor implementation.

Connectivity

Promise fulfilment is conditional on whether specific events occur. The following promise assumes economically and societally viable development of entirely new pharmaceutical systems: "In medical applications, nanomaterials will make self-regulating pharmaceutical dispensers compatible with biosystems so that they will not be rejected by the human body and will last many times longer in the corrosive and mechanically harsh environment of the human body" (Foster 2006, p. 229). The promise is implicitly connected to multiple inferences about the future, including a technological overhaul of drug delivery.

In other cases, promises explicitly depend on the fulfilment of other promises, or the occurrence of specific events. The promise "Once the bacteria (or other mutated organisms) learn to live with nanotubes (carbon or non-carbon) they will start using these nano-tubes to beneficial purposes for themselves, perhaps to fight with other bacteria in the hunt for food or for play" (Khadkikar and Irani 2006), found in a patent, is dependent on the bacteria indeed learning to live with nanotubes, a scenario the authors try to make plausible in the preceding paragraph. The promise's plausibility relies on the plausibility of the preceding scenario.

Conclusion

Promises are signals that can be used to establish trust and acquire valuable resources. However, ignoring the context of knowledge in promise-making can result in overpromising. To facilitate the evaluation of promises, we have presented a conceptualization of overpromises, highlighting their relation to other forms of promises. In addition, we have shown how promisees can question scientific promises by evaluating the knowledge context.

While we have focused on the conceptualization of overpromises, fully examining overpromising requires considering the promiser's identity, normative dimensions of the promise, and its specific context. Historical research on habitual overpromisers, as well as conducting interviews with promisers, could offer further insights.

Furthermore, understanding why overpromising persists in certain contexts requires further research, especially when both the promiser and the promisee seem aware of it. An investigation into such occurrences, such as within grant application procedures accepting inflated societal impact claims, would shed light on the underlying motivations and systemic factors perpetuating overpromising.

Funding • This work was funded by ERC NanoBubbles grant 951393.
Competing interests • The authors declare no competing interests.

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