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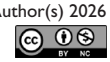
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"It's very not 'yes, and'": How scientists and science communicators deploy improvised comedy as a form of science communication

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Abstract

Over the past few decades, explicitly humorous or comedic science communication initiatives have become increasingly prominent. Within this context, a number of scientists and science communicators have chosen to deploy improvised comedy ("improv") which incorporates and foregrounds science as a form of science communication. This study of a small selection of international science improv groups aims to better understand the emergence of science improv as a form of science communication, including who is creating science improv, for what purposes, and with what consequences. The research highlights the tension perceived by many scientists who perform science improv between an inherently spontaneous theatrical approach and the "risks" associated with uttering scientific mistruths, as well as the ways in which scientists have attempted to mitigate this tension by either avoiding scientific content or diluting the artistic commitments usually inherent to the improv medium (i.e. the principle of "yes, and").

Keywords

science communication, science theatre, improvisation, improvised comedy, improv

1. Introduction

Over recent years, in several countries in North America, Europe, and Australasia, theatre performers, scientists, and science communicators have come together to produce regular improvisational comedy ("improv") performances which explicitly incorporate and foreground science. These initiatives are frequently emergent collaborations between improv performers and producers on the

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one hand, and practising scientists and science communicators on the other, often with the explicit aim of "doing" science communication through improv.

Like several other comedic science communication initiatives over the past decades, improv introduces a humorous element to science communication. There is the expectation that the humour, enjoyment, and entertainment which the medium of improv offers might enable an audience to better engage with and learn about science. In addition, it is anticipated that improv might provide personal and professional benefits to participating scientists by channelling their creativity and providing them with a new hobby while simultaneously improving their communication skills.

Unlike most other comedic and theatrical science communication initiatives, however, science improv is necessarily unscripted, spontaneous, and often demands substantial input from the audience; it is, therefore, a form of science comedy which is frequently dialogical by definition. Not only another instance of humorous science communication, science improv therefore also offers a fascinating insight into how scientists and science communicators navigate in real time the demands of "performing" science in dialogue with an audience within the clearly articulated constraints of an artistic medium (the principle of "yes, and") and without the safety net of meticulous preparation.

This paper aims to understand how science improv, as performed by a small selection of international groups, has been deployed as a form of science communication: how do performers and producers (both scientists and non-scientists) understand science improv; how do they understand the appropriateness of the medium for their individual and collective purposes; and how do science improv performers and producers navigate the tension perceived by many of them in marrying an inherently spontaneous theatrical approach with the "risks" associated with uttering scientific mistruths? Through an exploration of these questions, performers' and producers' implicit attitudes towards science and science communication are exposed, thereby revealing some of the broader challenges and opportunities associated with the combination of artistic media and scientific messages.

This paper presents a study of fifteen semi-structured interviews with performers and producers involved in four different science improv groups in different North American and European countries. Two of the authors (JD and OCM) have personal experience of founding and running science improv groups in different countries: JD as co-founder of, and performer in, two groups in North America and Europe, with additional experience of delivering improv training to early-career scientists; and OCM as an experienced improv teacher and performer, and the founder of a improv ensemble based in Europe with an international presence.

2. Humour, comedy, improvisation, and science communication

Classical humour theories provide a useful theoretical background to the function of humour in science comedy, and we outline these theories before briefly reviewing the literature on comedy in science communication, the literature on improvisational comedy, and the little available literature on how improv has been deployed within a scientific setting. We finish with an overview of the literature on scientists' motivations for engaging in science communication activities such as science improv.

Humour theories

The three classical theories of humour are superiority theory, relief theory, and incongruity theory (see Morreall, 1983), which are best seen as complementary rather than in competition. Under superiority theory (championed for example by Thomas Hobbes, 1968 [1651]), humour is

produced through the feeling of superiority we experience at the misfortune of others, or through the simple feeling of being superior to them. When used in science communication activities, superiority humour may be detrimental when the butt of the joke is part of the potential audience—jokes aimed at vaccine opponents may not persuade them of the benefits of vaccination, for example. When the joke is self-deprecating, for example jokes that rely on negative stereotypes about science, then the audience may instead find their stereotypes confirmed (Weaver, 2010).

Relief theory (most notably elaborated by Sigmund Freud, 2001 [1905]) posits that humour is produced by the relief felt when it is used to diffuse a tense situation, for example a joke told to alleviate an argument. This type of interpreting humour may be less obviously applicable to formal science communication activities, but it can be used as a way of breaking the ice and making audiences feel comfortable and relaxed, and in this way lower the barriers to achieving the communicative goals of any science communication exercise. Similarly, as Lockyer and Weaver (2022) or Watson (2015) note, relief humour helps social scientists in social research settings such as focus groups.

Finally, incongruity theory (e.g. Schopenhauer, 1958 [1844]) works on the assumption that humour is produced through the unexpected conjunction of unrelated and incongruous concepts. Some theorists (e.g. Morreall, 1983) hold that a measure of incongruity needs to be present in all humorous situations and the humour of the joke relates to how unexpected and surprising the connection is (Martin, 2007). For example, a pun works because of the polysemous nature of the central concept, and therefore, the pun can be read two ways producing radically different meanings (one of them usually innocent and the other one maybe more risqué). For example, the phrase "vive la Ω" was a visual pun on a protest placard at the March for Science reported by Riesch et al. (2021). This pun is an incongruous juxtaposition of the concept of resistance in physics and the concept of social resistance. In jokes about science, incongruity can also be constructed through, for example, the juxtaposition of empiricist and contingent interpretive repertoires (Mulkay and Gilbert, 1982), contrasting the seriousness of the subject matter with the playful irreverence of scientists' everyday interactions. Jokes relying on incongruity tend to assume some familiarity with scientific content in order for the conceptual link to be made, so its use in science communication similarly calls for some caution (Riesch, 2015).

Although the mechanism by which humour is created in science improv is not the explicit focus of this study, instances of humour corresponding in particular to incongruity and relief theory can be found to underpin the comedic element of numerous forms of humorous science communication, including science improv.

Comedy in science communication

The use of humour and comedy in science communication has become an established practice over the past few decades, with several forms and formats being used as a way of educating and communicating science through humour (Bankes, 2016, 2020; Carroll-Monteil, 2023; Little, 2022; Marsh, 2016; Pinto et al., 2015; Riesch, 2015; Simis-Wilkinson et al., 2018). Among the forms of comedy adapted to science communication are TV sitcoms, stand-up comedy, comedic theatre performances, and comics.

While there are influential voices that invoke the positive role that humour can play in science communication (Baram-Tsabari and Lewenstein, 2013), it is not always entirely clear what the benefits are (or are envisaged to be) nor whether these benefits are evident upon

empirical examination. Some commentators hope that humorous communication styles enhance the retention by the audience of the scientific facts that are being communicated. Indeed, some studies suggest a positive effect in this respect, for example on climate change communication (Brewer and McKnight, 2017). On the other hand, a study by Pinto and Riesch (2025) found no statistically significant effect on retention when comparing humorous and non-humorous popular science articles. In their extensive review of formal (school) science education Banas et al. (2011) found that the picture was similarly mixed, where the effect depends on the type of humour, the contextual setting, and aggressiveness of the humour. Research on humour in social media also points to the type of humour employed as a significant factor, with Su et al. (2022) finding wordplay and satire to be effective in enhancing engagement with Twitter posts, while anthropomorphisms were not. Regardless of the educational or emotional effect, however, humour can enhance the enjoyment of the communication activity—in Pinto and Riesch (2017) most readers noted they appreciated and valued the humour.

There are wider social and sociological issues arising with the use of humour to communicate science that relate to the wider workings and social functions of humour. For example, humour both helps strengthen group identities and accentuates divisions between those groups. As Michael Billig (2005) has argued, humour—and laughter—can be used as a mechanism of social discipline that punishes the behaviour of the person the joke is aimed at and influences their future behaviour to align more closely with the group's social norms. The use of in-jokes within a group can also function as a social marker for signifying who is in the ingroup and who isn't. In that context, for example, discriminatory or racist humour can sometimes be used to subtly test the audience's receptivity to the underlying sentiments (Weaver, 2011).

Riesch (2015) notes that specialist science jokes that rely on prior knowledge of scientific concepts can signal whether the listener has a certain level of science education. Thus, science insider science jokes, e.g. the visual pun "vive la Ω" noted above, may not be an accessible vehicle for science communication as they in fact rely on prior knowledge of science in order to be understood. For this reason then, if humour is to be used in science communication context, a special level of care needs to be taken in the construction of the humour.

In a more programmatic way, the stand-up comedy format has been adapted to science communication, most influentially perhaps by the "Bright Club" initiative at University College London (UCL), started in 2009 by Steve Cross (Bankes, 2020; Jahme, 2010). Bright Club recruited academics employed at UCL, trained them to present short comedy routines, and put them in front of a paying audience. The format proved popular and successful, and was franchised and imitated at a variety of other academic institutions in the United Kingdom and abroad (e.g. Roche et al., 2019 in Ireland). Science stand-up comedy and similar exercises were also pioneered in other countries, for example Portugal (Pinto et al., 2015). More recently, and outside of Europe or North America, comedy has also featured centrally in the Stemnovation science festival in Ghana (Osei, 2026).

The key distinguishing feature between stand-up and improv, the focus of this study, is, as the name suggests, the necessarily unscripted and spontaneous nature of the latter.

Improvisational comedy

Improvisation has long been part of theatrical tradition. Fotis and O'Hara (2015) cite *commedia dell'arte* (c. 16th to 18th centuries) and later Vaudeville and Burlesque (c. 19th to 20th centuries) as examples of theatre performance utilising improvisation. Contemporary forms of improv

theatre can be traced back to the seminal work of theatre academic and educator Viola Spolin and collaborators in Chicago in the 1950s and 1960s (Spolin, 1999 [1963]), and of the theatre educator, director, and playwright Keith Johnstone (1987) in the United Kingdom. Improv theatre is often divided into "short form" and "long form", a distinction which can be applied both to entire performances and to sections thereof and is not necessarily determined solely by duration. Short form improv more closely resembles the acting exercises from which contemporary improv developed. Scenes are often tightly constrained by a particular format, gimmick, or "game" and otherwise bear little connection to one another. Audience participation in the form of suggestions often provides the variable (and spontaneous) inspiration for each instance of the game or form. Long form improv may also be inspired by audience suggestions and may too be based on a particular format. However, suggestions may only be gathered sparingly (e.g. once at the start) and scenes are often linked—thematically, narratively, or otherwise—over an extended period (e.g. all, or a significant part of, any particular performance). A wide variety of both short and long form improv formats can be found in the online resource, *Improv Encyclopedia*.[1]

Improvisational theatre is often, though not exclusively, comedic. Audiences can find the spectacle of performers creating characters and responding to emerging (and potentially unanticipated, fantastical, and incongruous) situations extremely humorous. This is especially so on occasions where those characters and situations have been inspired or determined by the audience's suggestions (thereby also demonstrating to the audience the veracity of the claim that the performance is indeed spontaneous in nature). The games common in improv theatre often create further incongruity (McLaughlin, 2013). Seemingly unconnected concepts are intertwined in unexpected ways, and audience prompts can be particularly conducive to the creation of comedy if they are as unconnected from, and incongruous with, the extant scenario as possible. Superiority, meanwhile, is invoked through the often silly and potentially embarrassing situations the performers put themselves and each other into.

Among a wide variety of guidance and principles developed by the pioneers of improvisation, one of the most fundamental principles, and the one of greatest interest to the particular dynamics of science improv as explored in this paper, is the principle of "yes, and" (Leonard and Yorton, 2015). "Yes, and" is explained by Fu (2019) as comprising of three distinct but interrelated actions: "attunement", the act of listening to and being broadly aware of others; "affirmation", the act of accepting and agreeing with the idea, suggestion, or reality offered (implicitly or explicitly) by one's interlocutors; and "advancement", the act of building upon the proposition that one's interlocutors provide in order to make progress. The principle of "yes, and" demands, using an example from Leonard and Yorton (2015), that if the first improvisor notes that it is a particularly starry night, the second improvisor should not contradict this and instead should accept the fact that it is a starry night and make their own contribution building upon this (e.g. "I know. Things look so different up here on the moon"). By using the principle of "yes, and", performers achieve two important aims which facilitate successful improv. First, they can rapidly create a clear, consistent, and thus believable reality within which characters can interact. Second, they can readily identify a potential narrative through both a focus on, and directed response to, preceding suggestions. More generally, the principle of "yes, and" also speaks to a philosophy whereby every performer's contribution is listened to, respected, and incorporated, with shared responsibility for the success or failure of a scene and the generation of new (and hopefully humorous) ideas.

The "yes, and" principle is of particular interest here because it is implicated in the observed tension between the medium (improv) and the message (science). Whereas the principle of "yes,

and" might prompt a science improv performer to accept and build upon the premise or reality offered by a fellow performer, this sits uncomfortably with the possibility that the premise or reality in question might be unscientific, inaccurate, or otherwise "wrong". Of course, it is too crude to suggest that all successful improv necessarily adheres strictly to the principle of "yes, and", or to suggest that the veracity of scientific claims can always be so simply and clearly understood and communicated. However, this characterisation of both improv and science, as requiring an adherence to the clearly articulated principle of "yes, and" and concerning an absolute and objective truth, respectively, is broadly reflective of the perceptions of science improv performers and producers explored as part of this research. It is therefore likely to touch on broadly held, if ultimately flawed, views of both endeavours, and reveals the dynamics of how those who hold such perceptions seek to avoid or resolve this tension.

Whereas the use of improv for science communication is understudied (improvisation is described as "more of a technique than a format" in Weitkamp and Almeida's (2022) study of science-theatre in science communication), the use of improv as a form of communication training has garnered more attention in recent decades. Training in improvisation is now perceived to not only benefit theatre professionals developing performance skills (as noted above, short form developed from drama training exercises), but also to help a wide range of other people develop professionals skills in public speaking and engaging with audiences. For example, the Alan Alda Center for Communicating Science at Stony Brook University has for over a decade been using improv exercises to train scientists to better communicate (Alda, 2018), and improv has been used to help medics and medical students better communicate and collaborate (Chin et al., 2022; Rusiecki et al., 2023), training which the Alan Alda Center also offers (e.g. Kaplan-Liss et al., 2018). There is also a growing body of work, reviewed by both Fu (2019) and Gao et al. (2019), in the area of "medical improv" (Watson, 2011) which purports to demonstrate the positive effects of such training. These positive effects include improved scores in standardised patient examinations (Boesen et al., 2009) and self-perceived improvements in bad news disclosure (Kukora et al., 2020). However, the medical improv literature is deemed to consist of studies of "highly variable" quality (Gao et al., 2019).

Scientists' motivations to communicate

As will become apparent in the analysis below, the motivations scientists describe for engaging in improv as a form of science communication are reflective of existing research on why scientists, or people interested in science, engage in science communication (including science-theatre) more broadly. As Burchell et al. (2009) and others have found, professional scientists often face significant disincentives to participating in science communication activities, including: it being a distraction from an already intensive job which requires substantial amounts of time and effort; the lack of professional recognition for science communication (and even, at times, the perception by colleagues that scientists who devote time to science communication are likely "failed" scientists); and the lack of institutional support from their employers. Scientists who move into science communication professionally face higher job insecurity, lower pay, and lower social status (Burchell et al., 2009).

Reasons for why scientists engage in science communication activities despite these disincentives (see e.g. Pinto et al., 2015; Riesch et al., 2016) often involve the personal pleasure they get out of sharing their passion with others and enthusing especially young people about science, or even a sense of duty they feel for making their work available and understandable

to society at large. On a personal level, they may also cite the "transferrable skills" that they acquire when, for example, the particular science communication activity requires lots of public speaking, a skill that is professionally useful for scientists wanting to move on to become lecturers or professors. Institutional pressures, for example through the "impact agenda" for UK research council funded scientists, also features (paradoxically these institutional pressures often go along with the lack of institutional support cited above). In their study of science-theatre in a science communication context, Weitkamp and Almeida (2022) identify three broad categories of goals demonstrates by study participants choosing to engage in science-theatre, including "pragmatic", "fundamental", and "personal" goals. These categories, in particular, will offer a useful framework for understanding the motivations of research participants who engage in science improv.

3. Methods

This study aims to better understand the emergence of science improv as a form of science communication, including who is creating science improv, for what purposes, and with what consequences. To this end, we present a thematic analysis of fifteen semi-structured interviews. The interviewees were sampled from the performers and producers of four different science improv groups in different North American and European countries (Table 1), with all current and former group members invited by email to participate (see Supplemental Material for further details). The groups were all founded between 2016 and 2020. Two of the authors (JD and OCM) have themselves participated in science improv groups and were in some cases acquainted with the study participants. Therefore, the interviews were divided among the three co-authors of this study in order to ensure that no participant was interviewed by an author already known to them, and all participants were made aware of the make-up of the research team and how interview data would be shared within it.

Table 1. Interview participants.

Participant No.	Improv Group	Background
1	A	Scientist
2	A	Scientist
3	B	Marketing, with science background
4	A	Scientist
5	C	Scientist
6	C	Theatre owner, improv professional (non-scientist)
7	D	Scientist
8	C	Teacher (non-scientist)
9	C	Scientist
10	C	Scientist
11	B	Scientist
12	D	Scientist
13	C	Improv professional (non-scientist)
14	B	Engineer
15	A	Scientist

In order to keep the identity of our participants anonymous, we provide only limited contextual details regarding the four improv groups in this study. All groups are based in either North America or in Europe and, even though they are not all based in Anglophone countries, they all conduct their performances in English. Both performers and audience tend to draw from an international, scientific demographic who conduct their working life in English and who, due to the international nature of science, are probably more familiar with discussing science in English. This is not to say, however, that all science improv performances in Europe (or beyond) necessarily take place in English, and some of our participants mentioned other groups within their country that perform in the local language.

The interview questions were informed by our preliminary reading of the literature on humour in science communication and improvisational theatre, and we were therefore particularly interested in how participants conceptualised improv theatre, science communication, and the relationship between the two, while leaving enough space for participants to also add their own unprompted observations regarding their activities and thoughts. Thus with some small variations, the interview schedule (see Supplemental Material) asked the participants about their background, in terms of both science education and improv experience; their involvement with the science improv group and how the group came about; how they developed their science improv show and where inspiration for it came from, if relevant; the structure of the show and specific formats used; their views on how and whether science improv is effective or "good" science communication; and their views on science communication more generally.

The interviews lasted between 30 and 60 minutes, were conducted via Zoom or Microsoft Teams during the spring and summer of 2022, and, with the participants' permission, were recorded and transcribed. Quotes from the transcripts presented below have been cleaned of repetitions and filler words and phrases. The analysis was performed by HR (using qualitative data analysis software, NVivo) who does not himself have any experience performing improv or prior acquaintance with any of the participants. Preliminary analysis, which informed—but did not predetermine—the thematic analysis of the data, had previously been performed by JD on the basis of six interview transcripts, whereby possible emerging themes were identified through descriptive coding (Saldaña, 2021) and subsequent discussion between authors. The final coding frame was shared and discussed between JD and HR.

Ethical approval for the study was granted by the University of Cambridge's Humanities and Social Sciences Research Ethics Committee, and participants provided written informed consent prior to the start of any interviews.

4. Analysis

Participants, background, and show structure

Founders and participants—All four groups included were either founded or co-founded by working scientists, most of whom were postgraduate research students or postdocs at the time. Furthermore, the majority of performers within each group were also working scientists, although most scientist interviewees had at the time of the interviews graduated, moved on in their academic career, or left academia for jobs in various science-related industries.

Most participants indicated that their groups were founded with the intention of performing a regular improv show about science, usually with an explicit aim of using that show for science communication purposes. However, at least one show was set up in collaboration with a local improv comedy theatre, and the theatre in question did not necessarily share the scientist co-founders' explicit science communication goals (see below).

Origin and inspiration—Interviewees' specific interest in performing science improv was not necessarily the reason that they became interested in improv (or theatre more generally). Although this was true for some, most interviewees already performed improv and/or theatre as a hobby outside of their job or studies (i.e. unrelated to their professional identities) before beginning to perform science-related improv. Many interviewees came to see the science improv shows they developed as a mechanism of usefully and enjoyably combining their personal and professional lives, their theatrical hobby and their interest in science.

Although in general the groups assembled through the initiative of founding scientists who drew their inspiration from their prior involvement in improv and/or theatre, inspiration was also sometimes drawn from other existing science improv shows that participants were aware of. In some cases, participants who already performed improv joined existing science improv groups, or were instrumental in founding their own, when they moved cities or countries. Thus, while the individual science improv groups studied here all designed their own shows and devised their own solutions to the challenge of combining science with improvised comedy, there was a general sharing of ideas and movement of individuals that continuously brought fresh approaches and practices to individual improv groups.

Show structure—All groups approached the combination of science and improv in a largely similar manner. Rather than modifying traditional improv games to directly incorporate science—or rather than only doing this—all groups would invite a guest speaker (often a practising scientist) to give a brief presentation which would then serve as the inspiration for both short and long form improv. This practice mirrors the use of a "monologist" used in (regular) improv shows, whereby a speaker provides a monologue as the inspiration for subsequent improv.

Although all groups incorporated a guest scientist and included long form improv, these elements would tend to form the middle parts of the show. Shows would instead generally begin with short form improv as a way of warming up both the performers and the audience. Shows would tend to feature the guest scientist and subsequent long form improv, and finish with more short form improv. This combination of both short and long form sections was repeated by all four groups.

The use of scientists as guest speakers was perceived as beneficial for another reason: it allows the show to keep changing the science content by inviting different scientists on each occasion, thus keeping the show fresh and interesting even for regulars. As one participant noted, the fact that each show is different is of course also a general feature of improv. However, that the informative science content changed regularly, alongside the variations due to the improvised nature of the show, greatly enhanced this effect.

Audience—As the shows were generally amateur productions without a marketing function, they often relied on the guest speaker bringing their family, friends, colleagues and/or students to the show to form part of the audience. The inclusion of guest speakers' social networks was in some cases by design, particularly so in the case of the show that was initiated in collaboration with a local improv comedy theatre: "We thought, what if we created something by and for those [university] folks?" (Participant 6). While having a largely expert university audience might perhaps undermine a science improv show's science communication aspirations, this was not necessarily the case; audience members often came from business schools or branches of science other than the one being presented on any particular occasion. However, even when the audience was made up of those knowledgeable of the guest scientist's work, the show still functioned to make them and their work more relatable:

> I also think for example, students who come, who are working with these professors, with these scientists in their labs or in classes, I think it's a really great way for them to be a little more humanized than they might be, you know, if you just, like, see them for their lecture every week, or you work in their lab group. (Participant 8)

Thus, some shows would heavily rely on the guest scientists to provide part of the audience, particularly when the shows were starting out and had to build a reputation. The degree to which interviewees reported a reliance on these audience members varied somewhat; some said their audiences were almost entirely made up of friends and family of the guest scientist, while others reported that their shows would also attract other, sometimes even regular, guests. All interviewees however reported attracting audience members as absolutely crucial to the show's success (and bottom line).

The central tension: Improv truth vs "truth truth"

A central tension which these shows had to navigate was, quite simply, the combination of science and improv. As understood by a number of interviewees, science is about truth and improv about making things up on the spot, and as such they are perceived as fundamentally difficult concepts to combine. In the words of one participant, "science is over here and improv is over there" (Participant 8). Another participant conceptualised this problem by distinguishing between "improv truth" and "science truth", asking rhetorically, "how do you have the voice of science and the voice of like 'truth truth' versus the improv world or 'improv truth'" (Participant 1). Truth then, and improv's relationship to it, was a recurrent theme:

> In science improv we have a different relationship to the truth, I think, than you do in like musical improv or any other improv. Because there is a truth you're still trying to hold, and even if you're in a ridiculous reality, there is still a truth that you're still trying to convey and project through the work that you're doing. (Participant 1)

The implicit concern underpinning the central tension between science and improv was of inadvertently communicating a scientific mistruth, which was considered both likely and undesirable:

> So because in improv it's hard to know how things will go, right. That's the concept. So, of course, one challenge [. . .] was if we do something about the topic itself, how do we know we're not gonna send some wrong messages. (Participant 12)

However, this characterisation of these activities was also recognised as crude and not necessarily reflective of reality. As some participants pointed out, there are in fact, in their view, affinities and similarities between science and improv:

> Both improv and science are an exploration, a collective exploration of the unknown, something that you do with others and that you have to build on things together. I think it's 100% brings them together. (Participant 1)

Interestingly, this tension was also seen as liberating by one respondent, who felt that improv could be an "antidote" to the norms of scientific life:

> Improv in a way was an antidote to some of the ways of thinking and acting that you'd experience in your professional life. Clearly something like a scientific fact could be right or wrong. By which I mean, [. . .] by which I mean that you could say things which may or may not be scientifically correct, as understood by a consensus of scientists, for example. (Participant 14)

Although this respondent also admitted that he "hadn't really thought about it up to the point [the interviewer mentioned this]".

However, most participants agreed that there is a fundamental tension between the two forms of activity that impacted how the shows were run. There were therefore three key strategies through which the central tension was navigated: avoid, dilute, and ignore.

Avoid—One way of addressing the tension is to avoid factual science content, and instead focus on other issues important to science communicators, such as making scientists more relatable or communicating some of the excitement participants felt about doing science. For example:

> So that's also why we decided to have the performance maybe more about, you know, what it is to be a PhD [student]. Things a bit around where we felt the likelihood of us saying something completely wrong would not happen. (Participant 12)

Therefore, although the science improv show remains about science, it avoids a focus on science "facts" and concentrates on the lived experience of scientists doing research. The stakes of this alternative focus are thus considered lower. The quote from Participant 8, who we cited above as noting that the guest scientists' participation makes their work more relatable to their students, also exemplifies this point.

Dilute—Another way of addressing the central tension is to make compromises, not with the science content but with basic improv principles. The "yes and" principle was therefore occasionally diluted (i.e. no longer stringently followed), particularly when science facts were involved, for example by giving the guest scientist the option of intervening:

> . . . the PhD [guest scientist] that was presenting had this kind of option to stop [the scene] and say "no, this is not how it happens," or "this is not. . . it's like this this this," and explain. (Participant 12).

Sometimes, as above, guest scientists were given explicit control over the presentation of the science. At other times, however, the performers implicitly ceded control through their desire to "honour" the guest (i.e. to demonstrate their gratitude for providing the necessary inspiration for their show to function):

> If anything, it's understood that we are going to do some of that [i.e. interpreting the science] as part of our flights of fancy. But the good news is that if the grounding has already happened in the talk, I think there would certainly be an opportunity in the room for the scientists to make a correction or to make a clarification . . . (Participant 3)

Alternatively, the principle of "yes, and" could instead be diluted by performers directly without the intervention of the guest scientist:

> And then they're playing [. . .] and you say "actually, no, it wasn't quite like that because you're missing a point, this is dadada." Then they start playing again. (Participant 1).

Some interviewees who deployed mechanisms to dilute improv principles were aware of the contradictions inherent in these approaches. For example:

> [Correcting the performers is] so tricky. Like, that's the trickiest thing and it's very not "yes, and." It's very *very* not "yes, and." . . . I have found it very very tricky and it caused a lot of difficult conversations within the group. . . .within the [group] this was, there was a lot of controversy . . . (Participant 1)

The above quote is representative of scientists' willingness to modulate the medium to achieve their commitments to (a particular idea of) science and to (a particular idea of) science communication.

Ignore—Finally, the tension could simply be ignored, which is far easier if the risks associated with communicating a scientific mistruth are perceived as negligible. This was a view implicitly adopted by some of the non-scientists in our study, including theatre producers and professionals who were more familiar and at ease with the norms of improv in general than they maybe would be with the norms of science or science communication, and without any personal sense of loyalty to the institution of science or its public perception. In such participants' descriptions of the interaction between science and improv, the central tension identified above simply doesn't register:

> You know, improvisation is made up on the spot, there is no script. So in a quote unquote regular or traditional improv show everything is on the table, and so individuals can pull from their dating lives, their social lives, pop culture, you know, you name it, nothing is off the table. What we're trying to do here is to really stake up some ground that we wanted to stay in, and that is the sciences. And so, ensemble members and guests are less apt to reference Kanye West and Kim Kardashian than they are to reference thoughts, ideas, matters that are more specific to the sciences. (Participant 6)

Similarly, these participants also had a different perspective on how central or integrated science should be for the purposes of the show:

> My big kind of push for them was not to make everything, absolutely every single part of the show, science-based. Because. . . it gets to a particular place where the audience is sick of it, it is too much, [it] feels like we are trying to ram the idea of science communication down their throats. And it's like, nope, there's gotta be a good chunk of this that can just be fun. . . I'll definitely push for "don't force it" because the audience is going to know when we're trying way too hard . . . (Participant 13)

At least one scientist participant was ambivalent about the central tension because, to them, the conceptual distance between the science and the improv was clear and should be to the audience:

> I hope no one watched our improv and said, "oh yeah, that's what they were talking about in the monologue." (Participant 2)

For this scientist participant, even though monologue inspired the improv, conceptually the two were distinct and no attention needs to be paid to the central tension as identified by others.

Science improv as a form of science communication

Motivation—For most of our interviewees, science communication or public engagement with science was a key reason to create science improv. This wasn't always the explicit aim for all participants; some were more motivated primarily by performing improv simply as a form of entertainment. For those explicitly creating science improv as a form of science communication, they were motivated by the sense that contemporary scientists have a duty to engage in outreach activities, either because their job explicitly demands this or, more often, out of a genuine desire to give something back to society. However, participants also derived a personal sense of satisfaction from science communication, e.g. it enabled them to share their work and research with others. This range of motivations echoes previous research on scientists reflecting on other forms of science communication such as citizen science (Riesch et al., 2016) and science-theatre (Weitkamp and Almeida, 2022).

Science improv performers also felt that their improv experience generally helped them to become a better communicator, thus aiding them in other parts of their (professional) life as well. This aspect of improvisation was noted also by a number of interviewees. One interviewee in

particular (Participant 13), an improv professional and not a scientist, noted that he is personally convinced that improv has improved the lives of performers in many ways, a belief which led him to provide tuition not just to performers but also to ordinary people who would benefit from improv skills in their everyday and professional lives.

Science communication—We asked participants what they understand as science communication, including, in particular, what "good" or effective science communication looks like, as well as the value of science communication more generally. Some thought that science communication was important for a healthy society: knowledge about science helps "take control of the narrative [of] outright lying, propaganda, ah and I think we've seen a rise of this in the past five [to] ten years" (Participant 9); science is "an activity that is done squarely within the confines of society" (Participant 4) and as such society needs to know about it. The need for science communication to help combat misinformation was noted several times, as was the need to "raise awareness" about important scientific issues, thereby giving scientists a voice.

Good science communication was often understood to be about educating people, although only in part. Imparting knowledge was considered a key component of science communication, but within the context of improv theatre, it was also felt that it would be difficult to impart detailed knowledge (see below). Despite this commitment to an educational purpose, interviewees also frequently expressed a commitment to the importance of science communication being fun, and engaging people and inspiring enthusiasm about science; education is, in the words of one participant, an "intentional by-product of the event" (Participant 9). Science communication was also understood to be about "break[ing] down [. . .] invisible barriers" (Participant 8), and making science and scientists more relatable.

Improv for science communication—Participants were asked about how science communication, as they conceptualise it, fits with improv comedy. There was ambivalence over whether improv as a format is suited for science communication. As noted above, for some participants, the educative aspect of science communication was simply a by-product of a fun evening out. Where science communication rather than (pure) entertainment was considered the primary purpose of science improv, the format was therefore considered well suited by those who thought that good science communication is primarily about making science (and scientists) relatable. The format was deemed less well suited, however, by almost all participants for imparting detailed science-related knowledge. As noted above, participants felt that the tension between scientific accuracy and improv's inherent spontaneity makes the educative element difficult unless the moments when scientific information is communicated are kept strictly within the confines of the guest scientists' monologues.

Considering the different improv forms, some interviewees insisted that short form in particular is entirely unsuitable for science communication:

> I think with the science communication there needs to be some degree of education in it, in my opinion. You're explaining a concept, perhaps educating the audience, and we're not really doing that with the short form. The short form is really relying on people's existing knowledge of science and then we then sort of use it to, as a variable to sort of constrain what the performers can do. But in no way would I think [this is] about science communication. I mean, even if you're flicking through the periodic table and using that as a constraint for what people can say, people aren't going to be learning the periodic table using that exercise. (Participant 3)

Short form, however, was noted for its usefulness in getting the show started and getting improvisors warmed up for the long form sections (see above). Linking this with some of their wider view of what makes good science communication, for example highlighting the importance of

narrative and storytelling, interviewees would emphasise that short form—as opposed to long form—is generally not suitable for developing a narrative or story.

5. Discussion and conclusion

The purpose of this study was to explore and understand the recent emergence of science improv as a form of science communication: who is creating science improv, for what purposes, and with what consequences? Our interviews reveal that science improv is predominantly created and performed by scientists, often early in their careers, who were already familiar with, and interested in, improv as an artistic medium and an enjoyable hobby. Those scientists, like Weitkamp and Almeida's (2022) science-theatre practitioners, are motivated to engage their audiences with science; they perceive the science improv they create as a form of science communication. However, they express nuanced and varied understandings of what "good" or effective science communication looks like. For particular science communication goals, improv is felt to be ill suited; it is not the medium for educating the audience about science "facts". For other goals, improv is felt to be better (perhaps particularly well) suited; its humour, spontaneity, and interactivity help to ensure that the audience enjoy themselves and encounter science (and scientists) as approachable, relatable, and responsive to their contributions. However, science improv audiences are not hugely diverse, attracting many audience members with similar professional backgrounds to the scientists on stage. Even where a science improv show has been created with the explicit goal of science communication—rather than, say, science communication being a happy by-product of scientists performing improv about science—it therefore remains an open question whether that goal is achievable, and achieved, in context.

Perhaps the most revealing finding of this study is the perceived tension inherent in science improv between the "truth" of science and the potential scientific "mistruths" likely spoken during spontaneous improvisation. This tension was felt mostly keenly by the scientist participants, and the perceived risks associated with uttering potential scientific inaccuracies were considered significant (especially given some participants' sense that science communication's purpose is, at least partly, to counter prevailing misinformation). Although not always explicit, the perceived risk posed by the communication of inaccurate information related to science appears to be a risk to both society and to the scientific community. Non-scientist participants, although there were fewer, seemed less vexed by this tension and the associated risks, suggesting that scientists' professional identities, and the strong commitment to perceived norms which typically accompany such identities, drive this concern. This tension mirrors the concern sometimes voiced about science-theatre that it inevitably places "art at the service of science" and "privileges the accuracy of science content to the detriment of artistic quality", even if recent research has demonstrated that this concern is only a minor issue in context (Weitkamp and Almeida, 2022).

Scientist participants perceived the risks associated with the central tension between science and improv so great that they devised a number of strategies to address this tension. However, the strategy of diluting or modulating the artistic commitments usually inherent to the improv medium (i.e. the principle of "yes, and") might sit uncomfortably as a contemporary approach to successful science-theatre, where "having educational goals, and even making instrumental use of theatre. . . should not mean sacrificing the quality of art" (Weitkamp and Almeida, 2022, p. 49). When creating science improv for the purposes of science communication, some scientists in this study were willing to reshape the medium. Similarly, when forced to consider which elements of a show could be jettisoned while still ensuring that it functioned as a form of science communication, it is striking that all scientist participants would retain the guest scientist and, often, the resulting long form inspired by the guest scientist's presentation. Although

clearly those elements of the show which are most straightforwardly educative and informative and which offer the greatest scope to explore scientists' lived experiences, these are also the elements where the audience is least involved and generally does not itself provide ideas, inspiration, or suggestions to drive the content on stage.

Some of the challenges of using humour in science communication noted in the introduction also apply to improv. The risks associated with using scientific knowledge to underpin humorous incongruities suggest that successful science improv shows need to carefully navigate between humour which is more generally comprehensible and humour which might only be comprehensible to those with a scientific background (e.g. the students and colleagues of the guest speaker). Indeed, the importance of knowing and understanding the audience was therefore mentioned by several participants. Similarly, superiority humour relying on stereotypes of either (non-)science or (non-)scientists risks alienating the audience or misrepresenting science; some participants thus talked about the importance of avoiding ridicule in any direction. The tensions between the principle of "yes, and" and conveying a scientific truth may therefore be seen as representative of a wider issue associated with the use of humour in science communication, that the incongruities and/or superiority inherent in jokes about science always need to construct an alternative interpretation on a given topic. Without the existence of some kind of double-meaning, it is difficult to construct an incongruity, but the existence of a double-meaning risks scientific facts being misunderstood. Similarly, without some kind of (often dismissive) stereotyping, superiority humour can't be constructed, but the use of a stereotype risks damaging the image of science or undermining scientists' relationships with non-scientists. Seen through this lens, science improv groups' approaches to navigating the central tension offer further insight into the wider conversation about the potential perils of using humour in science communication and how they can be addressed.

This study reveals some of the challenges perceived by scientists, in particular, in combining an artistic medium with scientific messages, for the purpose of science communication as understood by those scientists. However, this study also highlights opportunities for science communication practitioners if a broader conceptualisation of the nature and purpose of science communication (as propounded by the research literature) is taken together with an appreciation of other theatrical media closely related to improv. As highlighted by Weitkamp and Almeida (2022), emerging participatory formats of science-theatre, such as immersive theatre and forum theatre (e.g. Caines and Heble, 2015), might align more closely with dialogical approaches to science communication. Without compromising the principle of "yes, and", which defines and facilitates successful improvised comedy, there is the scope, therefore, not only to explore formats for science improv which foreground audience participation, but also to experiment with performers as an onstage "public", thereby exploring, listening to, and celebrating interpretations and representations of science in front of, and in dialogue with, the audience. As one participant suggested,

> [with improv] you can mention topics and kind of explore maybe how they relate to people. . . it's easy to, for example, do a scene about someone that is exposed to science or receives science in a way that, you know, that relates to people . . . (Participant 12).

Indeed, on the basis of this study, it appears as if the potential for science improv to offer highly interactive, dialogical, and participatory forms of science communication, aligned with emerging (and as yet understudied) approaches within science-theatre, is both significant and as yet not fully realised. Future research would ideally move beyond this first exploratory study and widen the focus to include further examination of how science improv is being conceived, performed, and received by audiences (e.g. McRae et al., 2024), and should incorporate a broader range of non-English-language science improv groups performing beyond Europe and the Anglosphere.

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Ethical considerations

The University of Cambridge's Humanities and Social Sciences Research Ethics Committee (HSSREC) granted full ethics approval for the research (HSSREC reference: 21.289) on the 20th December 2021.

Consent to participate

Participants were provided with a participant information sheet and offered the opportunity to ask any questions prior to recording their written informed consent, including their understanding of how their personal data will be handled and their agreement to participate in the research, via an electronic consent form.

Consent for publication

Participants were made fully aware of the authors' intentions to publish the results of this research and provided written informed consent understanding and agreeing to the authors' intentions.

Author contributions

James A. Dolan: Contributed substantially to the concept, design, acquisition, analysis, and interpretation of the data; critically revised the article for important intellectual content; approved the final version of the article to be published; and agreed to be accountable for all aspects of the work and resolved any issues related to its accuracy or integrity.
Hauke Riesch: Contributed substantially to the concept, design, acquisition, analysis, and interpretation of the data; drafted the article; approved the final version of the article to be published; and agreed to be accountable for all aspects of the work and resolved any issues related to its accuracy or integrity.
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Data availability statement

The authors are unable to share the research data underpinning this study in a public data repository as the ability to do so was not part of the ethical approval application and participants have therefore not provided

their explicit consent to do so. Given that small number of groups and participants involved in the study, it is also very likely that sharing the research data would compromise the anonymity of participants.

Supplemental material

Supplemental material for this article is available online.

Note

1. https://improvencyclopedia.org/

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