# First report on lockdown questionnaire study

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### This is a draft and should not be circulated widely without noting that is not yet ready to be broadcast

In early 2020 the coronavirus pandemic forced a sudden lockdown on certain activities within professional science. We were interested in the consequences for science of the shutdown of national and international face-to-face (F2F) workshops and conferences and their replacement with remote communication (R2R). The context for this interest was a newly completed book manuscript which argued for the crucial importance of F2F for the institution of science and the danger, both for science and democracy, of the large-scale replacement of F2F with R2R.[[1]](#footnote-1)

Our initial view of the impact of the shutdown was that it would cause few problems in the short term, and that the change would be greeted with some enthusiasm because of widespread concern with the carbon-footprint of science and the inequalities that appear to be encouraged by the conference circuit. But we thought the dangers would increase in the medium term and could become extremely serious in the long term, where ‘long term’ meant the time taken for a new generation of scientists to grow up without face-to-face communication at a national or international level. We therefore set in motion a study using questionnaires (the method had to be remote given the circumstances), with a view to repeating it every 6 months for an indefinite length of time.[[2]](#footnote-2)

The two domains initially contacted for distribution of questionnaires were both from physics. The first was gravitational wave detection – a domain well-known to Collins – and the second was photonics, relations with which developed largely remotely as a result of a carbon-footprint motivated interest in cutting back on F2F, which had already led to a new model of international meeting, being referred to Collins for an opinion.[[3]](#footnote-3)

The questionnaire was demanding, with many open-ended questions, and we warned respondents that it would take them at least 20 minutes and possibly longer to fill out, and that we would prefer no response to a rushed response; some respondents took an hour or more to complete their responses. The questionnaire was also circulated at a time of immense pressure on universities as they transformed teaching into a remote operation and on other research institutions as normal interaction ceased. We thought that it would be a mistake to wait until times were a little easier before circulating the questionnaire: we wanted the first iteration to occur as near to the beginning of the enforced and unique change as possible. Unsurprisingly, the response rate was too low to justify any serious statistical analysis as we gathered only 42 serious and complete responses from the GW domain and 31 from the photonics domain. Even these numbers are inexact at the edges because it depends on what you count as sufficiently complete to count so all our reported numbers are qualified by ‘about’ or ‘c’ for ‘circa’). Nevertheless, the results were interesting with potential changes over time shown by repeated iterations of the survey potentially still more interesting. Most of what is presented here should be understood as following the methodology of a ‘probe’, investigating a ‘uniform’ form of life, rather than a statistically representative numerical survey. An iconic example of a probe would be the investigation of the location of the verb in the native English sentence: to discover that the verb comes in the middle of the sentence you need listen to only a haphazardly selected handful of speakers and all native speakers can verify the result. Probes are normal in much of natural science; for instance, when the Higgs boson was discovered it was assumed that there was uniformity among bosons and there would not be anything untypical about Genevan bosons![[4]](#footnote-4)

## Questionnaire and results

The questionnaire had three main sections and a fourth section designed specifically to inquire about events that pertained to the particular domains of GW and photonics respectively.[[5]](#footnote-5) The first section comprised ‘face-sheet variables’ including information that would allow follow-up questions. The second section was largely multiple-choice questions concerning the respondent’s current view regarding the switch from F2F to R2R. The third section comprise mainly open-ended questions asking about the particular benefits of F2F and about particular instances of where these benefits had shown themselves in the respondent’s recent experience.

Two respondents reported, in the form of private emails to Sapienza and Barnes respectively, that they considered the questionnaire to be biased toward F2F because the multiple-choice questions asked only about the potential disadvantages of R2R rather than the advantages. Here is one (edited) example of such a response:[[6]](#footnote-6)

I … wanted to try to bring to your attention that many of the younger researchers (let's say PhD up to senior postdoc like me) don't really consider conferences an entirely positive thing but your survey somewhat suggests that. As an example, your questions under #2 only allow "no effect" as the most positive option but I think less offline conferences will have a positive effect: less time wasted for travel or in talks about work that has been published + the impact on climate of course.

To many of the younger researchers, the main reason for being at a conference is that we are looking for a nice tenure track job and for obtaining one we need to ensure that we are considered part of the club by "the old guys" who are used to hanging out together at their annual club meetings around the world. This funny model might now change and, if we are lucky, we might be able to reduce the biased hiring practice in academia which has resulted in an embarrassing gender balance, to name the most obvious issue.

So, many of us are delighted that we can find a tiny positive thing about this COVID-19 mess: it helped to move conferences online as the abstract concept of climate change seemed to not have been enough to make us change our habits … Furthermore, with costs coming down we will have a lot more money for research and we can finally start including all the bright minds from around the world which have, thus far, not been allowed to join due to either financial or visa hurdles. And of course: we can spend more time doing research!

Just as a personal example, I was delighted that the ISEV2020 went online; I was going to skip it as 1500 Euros and all the time wasted to travel to Philadelphia and back did not seem reasonable. Now the meeting costs 150 USD and the flight and visa restrictions are minimal: I only have to walk from my bed to my computer to stream world-class research into my living room, that's fantastic! …

Though this was an early response, it came too late for us to change the questionnaire and, in any case, we think that the introduction to the surveys makes clear the advantage of R2R in terms of climate change while its irreversible role in academic life as a reinforcer of personal acquaintanceships seems obvious. Also, there are ample opportunities in the discursive sections for views like this to be written-in to the questionnaire response. Nevertheless, the fact that a bias could be read into the questionnaire might account for some of the low response rate. This response along with one or two others of the same kind do, however, make it clear that some scientists see the switch to R2R as entirely beneficial, and do not seem to have thought about the long term downsides of such a huge change to science as a social institution. Here we are trying to take a more distanced and ‘theoretical’ view from social science and, inevitably, this may look like a biased view to those more closely focussed on immediate events. Indeed, an initial enthusiasm for R2R in the absence of any immediate evidence of its downsides is exactly what is theorised in the paper by Collins, Barnes and Sapienza.



##### Figure 1: A ‘theory’ of the replacement of F2F with R2R

This ‘theory’ can be summarised in a diagram (Figure 1). In the figure, the X-axis is the extent to which a science is radically novel and/or beset by controversy of the sort that is best resolved by face to face debate and attempts to reach agreement that turn on developing new trusting relationships. In due course we will create a numerical representation of this characteristic of science but in the meantime we can say as a result of experience and discussion that GW physics lies well to the right on the X-axis and photonics, well to the left. The Y-axis represents the extent to which the domain is already characterised by dense trusting relationships – the more it is the less will be the negative impact of a shift to R2R be felt in the first instance. The Z-axis, running into the page, is time, running into the future. As a result of further discussions, we are beginning to realise that the element of the theory represented by the X-axis is too simple and that there are many additional differences between sciences that affect they way they use workshops and conferences even though the controversy/novelty dimension is the most fundamental.

The ‘theory’ is the cigar-shape running from front-top-left to back-bottom-right, which shows how massive displacements of F2F with R2R become harder and riskier with time. The disaster alluded to in the bottom right corner is the very institution of science changing into something else more like a social media debate as personal trust relations disappear and specifically scientific socialisation diminishes, as they cease to be reinforced and newly created as new generations of scientists come to be socialised into their professions in new ways without global personal contacts.

### 1a Some numerical results

We were expecting to find that young or less experienced respondents were more enthusiastic for a switch to R2R but, if it is the case, it did not show up in the data (with small numbers like these negative conclusions should not be drawn from absence of evidence). The main multiple-choice result from Section 2 of the questionnaire was encapsulated in two questions which are reproduced in Figure 2. Respondents were asked to check one choice in each column. A very quick way to analyse these results is simply to count up the number of respondents who checked the bottom right choice in the first question. In the case of GW this was 23 and for photonics 14 (55% and 44% respectively). To look at this the other way round, in GW about 45% thought that even *a complete abandonment* of F2F would not have serious consequences while in photonics it was about 55%. This is interestingly high – around half – in both cases. That is, around half of all the respondents, each group having recently experienced an online meeting/conference, believed that their science could dispose of all face to face gatherings which bring together otherwise distant colleagues, without suffering serious damage. This supports (one is tempted to say, ‘unfortunately’), the claim that in the short term there will be little felt loss resulting from by the abandonment of F2F.

 The difference in the results from the two separate domains gives some support to the claim about the need for F2F being more acutely felt in controversial sciences; while the numbers are too small to draw any strong conclusions we’ll find that the difference is more ‘tangible’ when we get to the write-in remarks reported under Section 5 of this report.



##### Figure 2: Main multiple choice question

A more complete way to analyse the first multiple choice question is to give a score to the choice in all four columns. We decided to create a ‘pro-F2F’ score with the highest score in the top right corner: if a respondent thought that replacing only 25% of F2F meetings would have a seriously adverse effect on science they would count as maximally pro-F2F. The following scoring grid (figure 3) was superimposed on the 16 possibilities.


##### Figure 3: The scoring grid

Each respondent’s aggregate score was divided by 30, which is the maximum pro-F2F score, giving a possible individual score from 0-1. Using this analysis, the mean score of the 42 GW respondents was about 0.4 whereas the mean score for the 31 photonics respondents was about 0.3, which is consistent with the result of the simpler scoring method and Section 5.

Turning to the second question shown in Figure 2, and, once more, asking it negatively, what percentage think that an abandonment of *90%* of F2F would *not have* serious consequences, we find:

**GW:** domain specific meetings c70% general physics meetings c80%

**Photonics:** domain specific meetings c70% general physics meetings c90%

Even though the numbers are small, they are consistent: fewer respondents think that serious damage will be caused by a 90% loss of F2F than by 100% loss and the loss of general physics meetings will be felt less acutely than the loss of domain specific meetings. This small difference between domain specific and general meetings is consistent with Tables 1 and 2 below.

### 1b Discursive results

In Section 1 of the questionnaire we asked respondents to say roughly how many conferences or workshop they attend each year under four headings, local and international, each divided into domain-specific and general physics. Averaging all the responses gives the following result:

|  |  |
| --- | --- |
| **GW physics** | **Photonics** |
| National | International | National | International |
| Domain-specific | General physics | Domain-specific | General physics | Domain-specific | General physics | Domain-specific | General physics |
| 1.3 | 1.2 | 1.6 | 0.8 | 1.2 | 0.8 | 2.4 | 1.0 |
| Ratio 1.1 | 2.0 | 1.5 | 2.4 |
| **From the original data, both groups travel around 5 times per year (4.9 and 5.3)** |

##### Table1: How often do physicists go to meetings

Section 3 of the questionnaire began with a list of reasons for scientists to travel to workshops and conferences gathered from previous research on gravitational wave physicists.[[7]](#footnote-7)

* Bumping into or otherwise meeting people who would not otherwise have been met;
* Seeing people in the flesh who were otherwise known as famous figures
* Building trusting relationships with new people;
* Speedily arranging new working groups with a level of commitment that would not have been managed on-line;
* Having discussions/arguments involving much more provocative but productive disagreement than could be managed on line;
* More easily avoiding authority associated with seniority in the course of debate;

Respondents were asked to add to this list if they wanted and then to consider up to the last three occasions they had taken advantage of these possibilities at local conferences (with dates) and then up to the last three occasions at international conferences. They were asked to describe the interaction each time. They were asked whether each was at a domain specific or physics-wide meeting. Thus, each respondent could describe up to six encounters of this kind, 3 national and 3 international.

Filling out this section of the questionnaire was very time consuming. One respondent who filled out his first three national encounters very assiduously, remarked, when asked to repeat the process for international encounters ‘Three, really, I haven’t got it in me’, and left that section blank. Regarding the entire section, of the 42 GW responses, 12 left that section completely unanswered and we do not know how many of these were meant to indicate that they had no advantageous experiences and how many indicated shortage of time (one did say he did not want to answer and, as we have seen, one decided not to answer to the second three questions). In the case of photonics, there were 5 out of 31 blank response to this section. The numbers of responses are listed on the following table (Table 2) but it must be borne in mind that the GW numbers might be understated by around 30% and the photonics by about 15%, this being without considering the understatement due to lack of time among those who did answer.

|  |  |
| --- | --- |
| **GW physics** | **Photonics** |
| National | International | National | International |
| Domain-specific | General physics | Domain-specific | General physics | Domain-specific | General physics | Domain-specific | General physics |
| out of possible 126 | out of possible 126 | out of possible 96  | out of possible 96 |
| 39 | 26 | 46 | 9 | 29 | 16 | 35 | 20 |
| Ratio 1.5 | 5 | 1.8 | 1.8 |
| Ratio (Table 1) 1.1 | 2.0 | 1.5 | 2.4 |

##### Table2: How often do physicists benefit from personal interactions at meetings

We can see from Table 2 that scientists in both groups get more advantageous personal contacts from domain-specific meetings than from general physics meetings but Table 1 has shown us that they go to more domain-specific meetings than to the more general meetings. The ratios are compared in the last two lines of the table. The only difference that stands out given the small numbers intimates that GW physicists weren’t getting much in the way of personal relationships from international general physics meetings but with these small numbers it would be rash to read too much into it. In any case, large international meetings generally work as an umbrella for the actual interaction of many smaller groups of domain specialists with their own mini-meetings; that indicates a direction for increased efficiency. There is nothing here to suggest that large physics-wide international meetings are *not* a place to start looking for savings on the carbon-footprint of science.

Table 1 indicates that scientists in both these groups go to about 5 meetings a year. We asked respondents to provide the rough date of each of their reported advantageous meeting encounters. In the case of GW about 100 out of 120 reported encounters occurred in the years 2016 to 2019 -- that’s an average of about 2.4 encounters each; in the case of photonics, the same four years covered about 75 out of 100 reports – that’s also an average of about 2.4 meetings each (bear in mind the doubts about understatement of the figures). In those four years, each physicist went to about 20 meetings on average, and it seems, therefore, they had an advantageous personal encounter more than once every ten meetings.

Remember, this is among groups of people, the more senior of whom, already know each other very well so there is less opportunity for advantageous encounters than there would be among strangers.

## Interim Conclusion

Suppose people are having advantageous encounters 2 or 3 times per 10 meetings they attend? Is this a lot or a little? It might be argued that it is wasteful and that it is not worth the cost of science’s carbon footprint and the inequalities detailed in the paper referenced above. Or it could be said to be more than worth it, especially if we could find ways of reducing the carbon footprint by making meetings more efficient and by lessening the inequalities by other means. The view being championed here is that it not only worthwhile but crucial.

## Qualitative results

Table 3 pulls together some of the advantageous personal encounters listed in the more qualitative face of the questionnaire. The remarks start from those of the most junior and work up to the most senior in order of reported length of experience in the domain. These remarks are purposefully selected to illustrate vividly the range of things that happen in these encounters. To reiterate, the methodological philosophy is that of the ‘probe’. It is assumed that experiences of this type are fairly uniformly distributed across the membership of the domain so that there is no need to be concerned about selecting a statistically representative sample.

As explained, this kind of social science is more easily verifiable than, say, results that depend on statistical inference or, indeed, natural or life science results in general. This is because, in a sense, members of the uniform community being investigated are already in a position to understand that community better than anyone! The social ‘science’ is a matter of theoretically informed and practised *reflection* on what members of the community already understand even if they do not already *know* it in an explicit way. This does not mean that every individual’s experience has to match the experiences reported here: there will be some members of the communities who normally never go to meetings, and there will be others who go to far more meetings than around 5 per year. For instance, Barry Barish, who is a Nobel Laureate for the discovery of gravitational waves, and who did not fill out the questionnaire, reports:

I looked at my calendar for last year, and I took 36 trips last year having 51 different stops.  The **main** reason for the trips -- about 1/2 were to give some sort of talk, 1/4 committees, etc, and 1/4 direct research trips.    It is disturbing to me that only 1/4 had to do with doing research as the main reason.
Being isolated for ~10 weeks, I have given 4 talks by Zoom, participated passively in 20 LIGO meetings, and worked on direct research  26 meetings.  Somehow, more research fraction, but it is misleading, because those are more passive meetings than research trips.[[8]](#footnote-8)

What is meant by saying that members of the communities can verify what is being said here is that they will understand the kind of thing that goes on in their community even if they are themselves outliers. At least, that should be the case where the reported encounters are straightforward, and these will often, but not always, bring to mind similar encounters of their own. Examples of relatively straightforward benefits of face to face communication found in the list below, include: meeting famous people and flattening hierarchy; settling disagreements in a way that would be hard to do over the internet; building new collaborations with people who are met by chance; doing the talking that gets projects finished; meeting potential employers, PhD supervisors, post-doc supervisors and PhD students; building trust among colleagues; discovering new reasons to distrust certain results; expressing doubts in ways that would be impossible in more formal settings; learning new experimental techniques and theoretical approaches as a result of chance encounters; encountering complex topics at presentations that would not be explored otherwise; serendipitous meetings of all sorts leading to highly positive outcomes; finding out why certain people will not talk over email and talking to them; speeding up complex interchanges that might take months over email and resolving them in hours.

Where the purpose of the encounters is less straightforward it may take some considerable reflection, theoretical study, or even discussion, for members of the community to agree that their world is, indeed, being represented. Where we talk of the importance of face to face meeting in the development and maintenance of *the culture* of a science, it is likely to be a less immediately obvious way of understanding the scientific world and references to this feature of the social life of science are unlikely to appear often among the reported encounters. A good example of rare existing self-consciousness of this kind is number 9 in the GW list below (GW9). That respondent is aware of how the cultural boundaries of the discipline are created and maintained in meetings. Comment GW19, also bears on the sense of community that underlies a common culture, as does PH2, PH15 and PH17. Of course, radical disagreements in science can arise out of cultural clashes between groups representing different communities *within* science (an extreme example being the ‘fringe’ of physics that still rejects Einsteinian relativity). Members of the GW and photonics domains can, then, verify what is being reported here, not by looking for evidence of statistical representativeness but by reading through the list of remarks below to see if they recognise the world being described.

|  |  |
| --- | --- |
| **GW** | **PHOTONICS** |
| **PhD student: less than 1 year experience****1)** At the Einstein Toolkit Workshop 2019, I had the **opportunity to meet** in person those whose research I had studied and whom I regarded as influential/famous in the GW domain, which had the effect of **flattening hierarchy** in allowing me to discuss with them.**PhD student: 2 years experience****2)**Had a **frank but productive disagreement** with a much more senior scientist, which would have been much more daunting and less easily resolved if it hadn't been face-to-face**3)**At a LISA cosmology group meeting, had a session specifically set aside to work on an ongoing paper, which had been dragging on for months with little progress, due to a large number of authors not communicating efficiently remotely. We had a **heated discussion which resolved a lot of issues** and brought the paper a lot closer to completion.**Postdoc: 4 years experience****4) Met students** at international workshop. Developed a new simulation during the workshop. Resulted in continued remote collaboration and a technical note. **5)Met potential new employer**, learnt about their research. When they advertised a position, I applied and was offered the role. **6)Met staff** who work on GW detector site and were impressed with my work. Gained their input on my experiment. Resulting discussion informed the development of the experiment and resulted in 2 (draft) papers.**Postdoc: 11-15 years experience****7)Extensive debate** in the continuous waves group about how to handle departure of the AEI Hannover members, which had occurred over open data philosophy disputes. Directions for evolution were discussed intensively and thoughtfully in a way not easily managed online.**8)**At the Boston LVC meeting, **encountering** many of the continuous-waves group for the first time, going to dinner with them, building mutual understanding as we wandered the MIT and Harvard campuses.**9)**Attending one of the “crackpot” sessions at APS reassured me that even though I may have crazy ideas, I was still operating within community norms and mores. **I could see the boundaries of physics more clearly — and accept them**.**Senior staff scientist: 11-15 years****10)Came up with an idea** for an experiment and thought through the practical limits to that much more quickly than would have happened with remote communication, while meeting up with a colleague/friend I used to work with but hadn't seen in a few years. **11)Frank discussion** about the shortcomings of a piece of software with the main authors in a way that would might have caused defensiveness/offense if done in a digital format where many uninvolved people would have been privy to the conversation. **Associate research scientist: 11-15 years****12)**A workshop brought together GW scientists as well as others slightly off-field, which **led to a wider collaborative effort** and also enabled me to learn quicker other aspects of the topic that I have not been aware of.**13)**I happened to listen to a talk by a brilliant young scientist, his work gave me the **idea of a new project**. We keep collaborating.**14)**Beyond giving my talk I sought out several colleagues who had information that could help one of my projects moving forward. These were **people who would not respond to email and had to be cornered**.**15)**Personal conversations at a meeting slightly off-field allowed me to **gain insight that was important** in making project-related decisions.**Assistant professor: 11-15 years****16)**Both I and my graduate student made contacts with astronomers we would not have easily been able to meet remotely; **free flowing discussion around a provocative result** was made easy by the collection of people and the ability to check in day to day on the issues; I could socialize with a person who I would later need to assess as a potential colleague.**17)**Got face time with important and famous scientists at meals; had informal conversations that allowed me to assess the research directions others were proposing**Control systems engineer: 16-20 years****18)**There are always collaborators who get easily miffed at the slightest hint of offense (even if none was intended). Digital and remote communication are terrible at dehumanizing folks to the point where you're barely even communicating with each other. There's really something about **sitting next to some one, letting them have it out with you, and getting the chance to explain oneself -- with body language included** -- that really helps smooth things over. I had a particular experience at this conference in Mar 2017, but I've had the experience several times on multiple occasions at many in-person collaboration meetings.**Research Fellow: 16-20 years****19)**An annual week-long retreat at the end of each year. This gathers 100+ students, postdoctoral researchers, and faculty from across 6 universities in Australia, and includes a student / early-career training workshop… The bandwidth of interaction between people - in group discussions and one-on-one conversations - would be virtually impossible to replicate through remote participation. **The social interaction helps to build cohesion and a sense of ownership in the collaborative enterprise**, particularly for new students joining OzGrav - again such interactions cannot be achieved remotely.**Research physicist: 16-20 years****20)**I was presenting some of my thesis work to the continuous wave search group at a F2F breakout, which I was essentially submitting after the LSC meeting. It was very useful to get in person feedback, as well as simply walk to a blackboard and answer some questions about it. What **might have taken a few weeks in e-mail chains** back and forth could be gotten over an hour in a conference room.**Associate Professor: 21-30 years****21)**I tried to have a face to face discussion at the CERN LVC meeting with my former postdoc advisor about a research and funding question that had been, and still is, troubling me. **This is a conversation that really can only happen face to face**, both to ensure I have their attention and so I can fully understand all the nuance of their response. I had a very brief discussion with him which convinced me that he just wouldn't have time for this discussion while he … [Held a certain role.]**Professor: 21-30 years****22)I met** VVVV and WWWW on a Royal Society event on multi-messenger astronomy. They are now trusted sources for astrophysics consultation and we hope to have joint projects with them in the near future.**23)I met** XXXX, who has a faculty position in Huazhong University of Science and Technology. We have discussed joint projects and he has recommended good PhD student candidates. We are now trying to have collaborative project through a forthcoming PhD student.**24)I met** with YYYY at IIT Bombay. I collaborate with already collaborate with her to some extent. In the 2018 meeting, we discuss an ongoing project which improved our mutual understanding of direction and goals of the project. We also discussed possible new projects and identified candidate student for internship to work on new project.**Professor: 21-30 years****25)**Working at another remote part of Italy ironically **brought together Australian colleagues** that allowed us to develop a different way of operating a detector.**Full professor: 31-40 years****26)Met prof. AAAA** … started a fruitful and long-lasting collaboration, in the field of wave phenomena that are chaotic in the classical (short-wavelength) limit, and radiation/scattering by regular-non-periodic geometries.**Senior Research Scientists: 40 years+****27)Drawing in a senior figure to a new group effort** requiring this persons' engagement | **PhD student: 2 years****1)**I went to a conference on my own initiative the summer before I started my PhD. About half of attendees were philosophers, and the rest physicists (except a few mathematicians). I made at least one new acquaintance, listened to famous speakers, **learned a lot**.**2)**I am new in the field and **got an introduction to the community** of people that works with related ideas. Much of the physics were too new to me**Professor: 4 years****3)**After presenting our work, I was approached by someone searching for a postdoctoral fellow position. We agreed on a formal interview and visit and **she is now working on my team**. **4)Building trust**: Getting to know the people behind the papers is always a great way to build up trust to discuss about disagreements more openly. Listening to talks and face-to-face discussion helped my understand key papers I had read but not fully understood.**Post doc: 6-10 years****5)**A student brought their friends who brought their friends, etc etc. A large group of students at a restaurant, we had a very nice informal gathering. We ended up adding many on facebook, and even **started a collaboration** with one of them. A colleague of mine was **invited** to one of their universities **to give a talk** too.**Materials research engineer: 6-10 years****6)**the researcher presenting the poster next to me immediately suggested a certain chemical functionalization that he has been working on. I went back to the lab, did a bit of background research to ensure it was sound, did the treatment and it worked. This enabled **rapid technological advancement** and 2 publications. **7)**I was presenting measurements of charged defects in a particular semiconductor. I, and the presenter just before me, presented **contradictory results**. we spent the next 2 days discussing and debating. Although we didn't come to a final conclusion that week, this encounter spurred us both to verify our experiments and within a couple of months, there was consensus. Without face to face discussion, which allowed each of us to gauge the legitimacy of the other's position, this disagreement would've bounced around the literature for an extended period to time, possibly years.**8)**This is a sensitive example. While at a conference, I encountered several researchers who confided that they were extremely skeptical about certain published results. Face to face interactions **allowed us to air these worries candidly**, exchange possible explanations, and discuss methods to verify the results. It is much less likely that one would state these concerns as openly in an email, which would leave a formal record, or discuss them in an online forum that would include many unknown participants.**9)**After presenting my experimental results, I had a brief chat with a theorist. He explained a couple basic principles of my experiment that i was not aware of. This discussion, on its own, was not significant. But, the next day, I was strolling along the grounds of the meeting place, enjoying some fresh air when I encountered this same theorist. We began a **friendly conversation that soon became a significant, fruitful, and deeply informative collaboration**. Clearly, this interaction and building of a rapport would not happen online.**10)**I saw that I would be attending a conference with a potential collaborator. I was familiar with this person's work and contacted them via email beforehand. We discussed various topics and agreed to meet at the conference. Only at the conference did this researcher confide that certain informal collaborations and research agreements limited his ability to collaborate with me. However, we have since been in somewhat regular contact, **shared "the inside scoop"** about the validity of certain research, and vetted each other's ideas. This was a clear demonstration that email contact lacks what in-person interactions add.**Group leader: 6-10 years****11)**I bumped into colleagues who introduced me to other colleagues … and quickly we got well along and **elaborated a research plan** that converted in a short time in a project proposal.**12)**After my talk, I was **approached by a scientist in the audience**, who later become one of my best friends and collaborators. **Associate professor: 11-15 years****13)**Met in person with important people in a **related but separated community.** Started interesting discussions.**14)**Got up to date with the situation in my own speciality field. Managed, via face to face discussion, **to finalize an important international collaboration**. Reinforced friendship with people I don't see enough outside conferences.**15)**Made **contact with a part of the community that, since they are based on the other side of the planet**, we don't interact enough with. Very interesting spontaneous discussions.**Assistant professor: 11-15 years****16)**In this meeting I benefit from the following two items:Building trusting relationships with new people. I have met two or three potential collaborators who I have never met before. I introduced my group projects and discussed the potential for collaborations, which is currently under planning. **such collaboration would be more difficult to plan without face-to-face discussion**, as e-intro is harder to engage people; Having discussions/arguments involving much more provocative but productive disagreement than could be managed online. I also discussed scientific questions with other participants and clarified some of my questions on their research. I don't think we fully reach agreement and kindly pointed out my doubts which she mention that they are interested in addressing them in the future**Associate professor: 11-15 years****17)**During a SPP in Ottawa, I get to know a person, that I greatly appreciated scientifically, during the cocktail party. He was very friendly, and I was very glad he spent some time with me. **I felt part of a community****Reader in physics: 11-15 years****18)met a colleague**, started a discussion, which lead to a first experimental test, then a proposal (failed), and a paper. Now after 8 years we keep in good contact, we meet a conferences and once or twice per year in person.**19)**photonic conference, watched a presentation before mine, on material science, and got intrigued by the material that was presented. after had a chat with the speaker, got a sample, started a collaboration. now 5 years later it is one of my main research line, it was the material I needed to develop the network lasers I wanted to explore. **Pure serendipity**.**20)**Invited at a conference, and given my talk I started **wandering into different rooms**. Went to a talk in a different field, and after started discussing with the presenter, now we have funding together and a great collaboration**21)**During my phd, ended up **talking to a weird colleague**, who was chain smoking, and was getting excited by scientific discussions. Everybody was respecting him a lot even if his appearance would not have convinced you. He was a visionary, a great man and scientist with whom I had shared so many exciting discussion, often at a conference, often late at night. He does not reply to emails, he is not a R2R type**Associate professor: 16-20 years****22)**I met a peer colleague who left the lab I was working in before I joined it. i always heard of him, I could never talk to him. **now he is one of my best collaborators**.**23)**I met very a big boss of my field, who turned up to be a nice guy. **I am writing a EU project with him** and my best master student ever is doing his PhD with him.**Professor and group leader: 16-20 yrs****24)Meeting in person was crucial** for the theorists to know we could perform new types of experiments and to realize the common interest. Online contact with such a busy person would not have worked out.**25)Discussion with a theorist** in my field in a small-scale workshop. After his talk we realized that some of his predictions could potentially be realized in our experiments, in a different context. We are slowly starting a collaboration. I would never have listened to such mathematical physics talk, very much out of my comfort zone, if it had not been a presencial workshop.**26)Discussion with young researchers** (PhD students and postdocs) in the poster session and social events of one of the major international AMO conferences made me aware of technical difficulties and details in experiments we plan to do on the long term in my group. These very technical discussions would have never started online, but were crucial for us to design correctly a new experiment apparatus. Such technical exchanges are very important for experimental research, and cannot occur locally if you are the only person working in a specific topic in your country.**Distinguished professor: 31-40 years****27)Collaboration** with Univ of Rome started after meeting at a conference**28)**Led to **collaboration** with Univ of Cincinnati and still continuing**Professor of photonics: 31-40 years****29)**National Project meeting. This was a gathering of approx 15 staff, and 15 PhDs/postdocs, Advantages were: renew contact with existing colleagues, meet some staff I had not met before, meet new PhD students and post-docs, **established a new informal collaboration** (still on-going).**30)Witnessing open differences of opinion**, challenging but always friendly - enabling controversial areas to be identified (by me). |

##### Table 3: Advantageous encounters at meetings

## Who have you met?

Respondents were then asked:

Can you name and new trusted friends or acquaintance, not from your own local group, who now work with in [GW/photonics], that you first met in any of the meeting you have mentioned.

Not everyone was prepared to answer this question because they found it intrusive or because it was too time-consuming, or they could not remember, and so forth. Nevertheless, including names mentioned in the responses to the earlier questions, GW respondents mentioned a total of about 110 new trusted working relationships while photonics respondents mentioned 60. We can safely assume that the true numbers would be considerably higher than this and it seems probable that such relationships would not be generated under R2R, at least, not in such large numbers. One GW respondent wrote in spontaneously:

One thing I've noticed is that large organised remote meetings do not allow you to interact one on one with other members of the group. You are either listening to one person or taking to all people. That is what I will miss unless smaller interactions are specifically organised.

Just to add some colour, one photonics respondent wrote in response to the ‘Who have you met?’ question:

[I met XXXX] (USA). I had never met him before - we are now working towards a collaborative project. We got to know each other in the queue waiting for a conference dinner.

## The final write-in – GW and Photonics diverge in their responses

The final question is Section 3 of the questionnaire invited respondents to:

Please add any comments you like regarding the questions and your answers, especially anything that refers to how you might manage now that face to face meetings have been shut down.

14 from the GW domains and 15 from the photonics domain availed themselves of the opportunity. In their responses to the earlier parts of the questionnaire the two domains have been fairly similar, with just enough divergence to give some support the hypothesis that more controversial fields (GW being the more controversial), would find more value in face to face interaction. But in these volunteered responses the divergence in content was more striking. While GW scientists are aware of the global warming problem and would like to reduce their contribution to it that arise from meetings and conferences, not a single respondent complained about bias in the questionnaire and only one made a minor positive comment about the fact that science could be done remotely but otherwise all remarks were about the problems that the shut-down of F2F would cause. In contrast, 10 of the 15 PH responses favoured the switch to R2R. Table 4 shows a selection of the more graphic responses from both groups, following the format of Table 3 in listing responses in ascending order of years of experience of the respondent. Remarks that indicate problems in the loss of F2F are marked **(X)** while those that are more positive are marked **😊**. Sometimes both sentiments are found in the same response.

|  |  |
| --- | --- |
| **GW** | **PHOTONICS** |
| **Professor: 3 years experience****(X)**Hard to make new collaborations/working relationships via zoom meetings which are time limited and formal**Postdoc: 5 years experience****(X)**I think a very important aspect of these international F2F meetings is the ability for less senior/new researchers in the field to interact and meet senior field members. The friendships that can be fostered between new researchers between various groups is also very important. These occur naturally during the downtime that a F2F meeting fosters, and I believe is very important, and this is an aspect that suffers greatly during online meetings.**Assistant professor: 11-15 years****(X)**I think it will be very difficult to expand my circle of social and professional connections. There is something important about in-person meetings, where body language can be read and expressed, where you can go on social outings, that is hard to replicate remotely. Even questions asked following remote talks are fewer in number, shallower in content, and harder to engage with than in-person questions. I have always felt that interpersonal discussion was a strength of mine, in teaching and research, and I find that I am a weaker communicator through remote means. I think writing splashy papers, managing social networks, and advertising on digital platforms is going to be necessary to get exposure nowadays. I'm not sure how I will manage, except that I believe this crisis will be short lived and there is a real appetite and need for in-person communication. I think things will get back to normal within a year.**Lecturer: 16-20 years****(X)**One thing I've noticed is that large organised remote meetings do not allow you to interact one on one with other members of the group. You are either listening to one person or taking to all people. That is what I will miss unless smaller interactions are specifically organised.**Professor: 21-30 years****(X)**It will be much more difficult to identify potential new collaborators and to establish links with such persons. If only R2R meetings can take place in the next year or so, then I will have to adapt to the situation and make an effort to discuss new thoughts and ideas with a wide array of people. If the impact of COVID-19 will clearly only impact a fixed period (~1 year or so), then I may also choose to just focus on current projects and wait until F2F meetings are possible again to start new discussions and project.**Professor: 21-30 years****(X)**This is difficult as the senior leadership is comprised of people I know since 10 to 20 years and I don't recall where I met most of them first. And the meetings I go to are typically restricted to project members or even to subsets of the project members with signed NDAs. So the chance of a new person showing up over the last months was very limited. But the point that you can't create trusted friendships in zoom meetings is appreciated.**Senior Research Scientists: 40 years+** **(X)**There are many things I do best which I cannot do involving forming consensus in particular. **😊** However, there is also a lot of science possible with telemeetings and I welcome the fact that this shock therapy has taught us all how to do it and the value possible in it. | **Postdoc: 5 years****(X)**I've met people through online tools, but I can't say they are trusted friends, as I haven't met them face to face.**Research associate: 6-10 years****(X)**It will be very hard to make new friends. Probably will build on past acquaintances and collaborators. Follow more people on LinkedIn and Twitter and start participating in their online posts and tweets.**Oberassistant: 6-10 years****😊**I sincerely believe that the lockdown has enabled the online conference concept to be tested , since the appeal for reducing our contribution to climate change did not sway the general community. I think the silver lining of this pandemic situation is that more conferences will swatch temporarily to an online format which I find brilliant. On the one hand, the amount of time saved by not having to travel, apply for visas, is outstanding. On the other hand, the cost of conference attendence has drastically dropped, opening up for more people from different communities to expose their ideas! I call this win-win, that means more time and money can be spent in what really matters: research.**Group leader: 6-10 years****😊**Tools for remote meetings are very advanced and effective nowadays. I've been using Zoom, WebEx, Microsoft Teams, GoToMeeting etc. They are very effective. It is alsmost as meeting with people face to face.Well....perhaps online virtual conferences will work....I'm goingt to have my first experience in a few days. **Assistant professor: 11-15 years****😊**I'm still working within an orbit of people I earthier already know, or whose name I know. It has been a pleasure to find out how many of those I didn't know, but whom I have contacted, have been very open to discuss by email/Zoom etc..perhaps out of a common sense of making the most of opportunities we have. **(X)**What is of concern to me is that the kind of on-line meetings I have been involved with so far don't let me mix with PhDs and post-docs. I'm not hearing about their work (form them) and I don't have the easy coffee-time, poster-time to mix with them. I worry about that.**Researcher: 11-15 years****😊**Retrospectively, many conferences and workshops that I have attended turned out being quite useless - in the sense that it did not give rise to new collaborations or new ideas. I could have easily spared this time. The proliferation of workshops and conferences, starring few (but often the same) keynote speakers, especially in photonics, is very worrying. I will be interested to see the associated carbon footprint (as, e.g., in https://github.com/milankl/CarbonFootprintAGU).**(X)**Reducing face-to-face meetings is without doubt necessary. At the same time, I am concerned by the fact that virtual meetings might proliferate even faster, leading to a medium to high overall carbon footprint (the rebound effect) and to the promotion of key figures to the detriment of young researchers. The mutual interaction between young researchers (PhD students) - which is essential to federate a long-standing community - will be lost if virtual meetings follow the same strategy as for physical meetings. **Associate Professor: 16-20 years****😊**lockdown is only 2 months... so this last question does not make sense. If lockdown would last 20 years, who knows? We will find strategies to know people... social networks... online chats... we know that lockdown is not forever, so we do not put any effort in solving such temporary problems.**Reader in theoretical physics: 16-20 years****😊**With regard to the previous question, I think it would make more sense to talk about people that I now work with who I met through means other than conferences. I have many collaborators, and I don't think I met any of them for the first time at a conference. I have met several because they came to give a talk at my institution, or because I came to give a talk at their institution. I've met several through introductions (i.e., they knew somebody who I knew). I've met some because I simply sent them an e-mail. And the rest I've met because of some more formal association between my institution and theirs. I've had important conversations with these people at conferences, but I see the value of the conferences as being primarily social and reputation-building.I told Bill Barnes about this, but I feel like the overall construction of this survey reflects a rather strong built-in point of view. The questions seem designed (maybe not deliberately) to lead to certain conclusions, and I feel like much of the way things are being asked misses the point of what's going to be a necessary transition to more virtual conferencing in the future.**Reader in theoretical physics: 16-20 years****(X)** The greatest loss is in the informal discussions. Most of the proposed online conferences I have seen have only included talks and Q&A sessions. This cuts out the actually valuable part of the discussion. **😊** I think such discussions could be possible, but they will require real effort to create them.**Professor and group leader: 16-20 years****😊**We are currently holding the meetings with theory collaborators online. This works well because the collaborations were already established before lockdown. Establishing new collaborations online would be hard, but maintaining existing ones is in some aspects more efficient.Lockdown has positive aspects for people working in not so well connected countries like mine. It is much easier to invite people to give talks online than to get them to visit in person. It is also possible to attend every week seminars from leaders in the field (that otherwise would never be broadcasted online). It would be very positive for our research if these initiatives would stay in place after the lockdown ends. They could strongly reduce our need to travel.**Distinguished professor: 31-40 years****(X)**Opportunity to meet young people and inspiring and mentoring them is important part of conferences in addition to fruitful discussions and these leading to collaborations. **Professor: 31-40 years****😊**Until the the 1990s, scientists around the world could not attend more than a couple of conferences a year. So they were special and important. In the past 25 years, conferences have become a business, and research has become a market, not just an academic pursuit. We have excessive number of meetings where we meet the same people and hear variants of the same talks. Invited talks are a dime a dozen. It has become a waste of time and polluting. The Covid has given us a chance to see that more clearly. For those who thrive in the market approach to science, the R2R might be a solution. I am happy with just fewer but more meaningful meetings. |

##### Table 4: Final write-in concerning the impact of the shut down

This difference in reaction between the two fields, still obvious even when we take into account the very small numbers and the way the remarks have been selected, needs explanation. It could have to do with the divergent nature of the two domains and the relatively high level of debate about the issue within the photonics domain, where the first Photonics Online Meeting (POM) was held in mid-January 2020, before the pandemic had taken hold, motivated by concerns over global warming, and the success of which has been much discussed since. In contrast, the first online meeting for gravitational wave physicists was forced by the lockdown and took place in mid-March 2020. The difference in self-consciousness has to be a confounding variable if we are trying to explain the divergence found in Table 4

The sciences in question are also quite different. Gravitational Wave detection has been a single issue international science, depending on the building of one or two hugely expensive apparatuses, the field spending about a billion dollars, with an aim that was always seen as almost impossible to achieve, and with no direct practical applications, and therefore born in hostility and controversy, which lasted the nearly 50 years to the moment of acceptance of the discovery. No such science could survive without a strong sense of community uniting all the specialist fields within its domain and the maintenance of a strong boundary between the inside and the outside; the need for continual face to face meetings is bound to be felt strongly in such a domain. Photonics, on the other hand turns on bench-top experiments based on the same basic science of the interaction of light and matter with no more than the usual controversies that accompany any experimental science, but open, in principle, to relatively cheap replication tests even though such are often subject to the vagaries of tacit knowledge transfer; the results have a wide range of practical applications and a wide set of interested communities which makes it and its meetings open to commercial exploitation of various kinds. These differences between the sciences, add to what is labelled ‘novelty/controversy’ on the X axis of Figure 1

## The broader problem of building and maintaining a culture.

The book which inspired this inquiry turns on a table of the functions of face to face meetings. Twelve functions are divided into four categories working from the most profound and less immediately obvious to the more readily apparent. These four categories are:

1. Forming society
2. Trusting individuals
3. The use of presence to create and modify meaning
4. The presence of the body to promote efficiency and create energy

Much of what is found in that table has already been mentioned in the table above, but not mentioned, but found in Category 4, is the very fact that the willingness of people to expend the time, trouble and expense of attending a distant, narrowly focussed, meeting can itself bring energy to a new initiative which might otherwise fade away if supported only by remote communication. One can see why this kind of subtle effect is not mentioned in the responses: would you think about it if you, yourself, had not tried to develop a new and difficult project from scratch?

It is the first category that is the hardest to articulate without a lot of, often, social science informed, reflection. The easiest of the three sub-elements in this groups, is the transfer of tacit knowledge which happens best, or only, with face to face interaction. The next most difficult element in the group is the acquisition of ‘reliance’. Reliance is like trust except that you do not notice it since it is just a constitutive part of your social life (no more noticed than water to a fish), whereas you can describe who it is you trust and, perhaps, how you came to trust them. Reliance, describes elements in the unspoken part of culture. It is what allows you to hail a cab or ride on a bus without thinking about whether the driver can be trusted not to rob you or drive like a maniac (note that Uber is, to slight extent, shifting this transaction a little way from reliance toward trust). The third element in the group is the most subtle of all, since it points to the way the distribution of words and silences in speech, over and above the explicit meaning of sentences, is an almost impossible to notice but major contributor to the establishment and maintenance of culture.

It is argued here that it is the loss of what happens in this first category, that would accompany the abandonment of face to face meetings in science, that would, in the long term, be the most dangerous. Science is science not social media, because of its culture. And within that overall culture, which turns on integrity supported by trust, the culture of any one science, and the boundary that separates it from its fringe, is developed and maintained by ‘socialisation’ and that happens in face to face interaction. An essential feature of science is that it endeavours, and largely succeeds, in maintaining, at the highest level, a global bubble of uniform culture, within and across the diverse national cultures of the world. The cultures of the individual sciences are embedded, fractal like, within this high-level culture. Developing and maintaining such uniformity within diversity is not an easy thing to do.

As far as some of the less profound aspects of the four categories of the functions of face to face interaction are concerned, it is possible to imagine ways of replacing them in a world of R2R though it might be safer to try to ameliorate the manifest downsides of F2F in other ways. But is not possible to imagine how that transnational bubble of culture and those embedded but still transnational bubbles of culture that constitute individual sciences, could be maintained without F2F. If they cannot be maintained, then the boundary between science and social media will dissolve. That would be a tragedy not only for science but for the world.

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1. Collins et al: *Face-to-Face: Communication and the Liquidity of Knowledge*, under submission. [↑](#footnote-ref-1)
2. A short article setting out the view that the difficulties would be revealed only in the medium and long term, co-authored with our two partners in the photonics domain, is Collins, Harry, Barnes, Bill and Sapienza, Riccardo, 2020 [↑](#footnote-ref-2)
3. Sapienza had organised the new kind of conference while Barnes was the instigator of the three-way cooperation, having attended a seminar presented by Collins some years earlier. [↑](#footnote-ref-3)
4. For the distinction between probes and surveys see Collins and Evans 2017, and Collins, 2019, and see the later, esp Ch 9, for the use of statistical outcomes in an illustrative way based on the ‘tangibility’ of the processes being investigated. [↑](#footnote-ref-4)
5. Responses the fourth sections did not produce any interesting or novel data. [↑](#footnote-ref-5)
6. A persuasive paper dealing with the disadvantages of F2F conferences and meetings is available here: [https://www.biorxiv.org/content/10.1101/2020.04.02.022079v2.full.pdf](https://eur03.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.biorxiv.org%2Fcontent%2F10.1101%2F2020.04.02.022079v2.full.pdf&data=02%7C01%7Ccollinshm%40cardiff.ac.uk%7C5f74a11aad3147468b6b08d7fc3a2157%7Cbdb74b3095684856bdbf06759778fcbc%7C1%7C0%7C637255199643056227&sdata=zXiBGJSuPnhXarZBR1%2Bl8zEosUVXfFyytpsyzh0Cqc4%3D&reserved=0). This paper has impressive detail covering many more of the disadvantages of the current conference system and how they could be avoided in a switch to R2R, but shows no awareness of the potential wider social consequences of such a radical change to the social system of science. [↑](#footnote-ref-6)
7. And reported in Chapter 9 of Collins, 2018. Respondents were asked to complete Sections 1 and 2 of the questionnaire before looking at Section 3. [↑](#footnote-ref-7)
8. Personal email to Collins, 27 May, 2020 [↑](#footnote-ref-8)