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Transforming tradition: how the iconic Christmas Lectures series is perceived by its audiences

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ABSTRACT

The Royal Institution Christmas Lectures are a landmark in the history of science communication. With today's changing media landscape, it is important to know who is currently watching, how they are watching, and how they are perceiving the content. This cross-sectional study evaluated perceptions of live audiences, people watching at home via Twitter, and awareness of the Lectures by science-interested audiences. The Lectures are valued by science-enthusiast audiences for performative identity sharing and valued tradition. However, younger generations are shifting away from traditional television to online videos, and the Lectures must adapt to remain relevant to new audiences.

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Christmas Lectures; science events; media landscape; evaluation

Introduction

The Royal Institution Christmas Lectures are an internationally known landmark of the Science Communication landscape, and have been described as the pinnacle of public engagement with science (Gjersoe & Hood, 2013). The Lectures are described as the birth of science communication in its modern form (Mulder et al., 2008); the first publicly visible attempts to communicate science to audiences who were not already participating as scientists.

Based in the UK, the Royal Institution (Ri) holds an annual series of three Lectures, each based on a single topic intended for a young general audience. Faraday initiated the Lectures in 1825, and it has run without interruption, except during World War II. The Lectures were first broadcast on television in 1936 and have been on television every year since 1966. They are one of the longest continuously broadcast science programmes on television in the UK and the world's oldest science TV series (Ri online, 2019) and now reach an audience of millions each year (Ri, 2020 personal communication). The event takes place every year in mid-December at the Ri headquarters. Tickets to the live recording of the Lectures are available exclusively to Ri Members, Young Members, Patrons and UK registered schools, via a ballot which opens in September (Ri online, 2021). Historically, before they were broadcast on television, only a very small number of people were able to witness the Lectures. As more people came to own televisions, and as technology has developed to allow for video hosting on the internet, there has been increasing opportunities to make the Lectures available to a larger audience.

The Lectures are currently broadcast in the UK on BBC FOUR (a channel aimed at an educated audience) immediately after Christmas, on three consecutive days. They are aimed at children aged 11–17 years old (Ri, 2020 personal communication).

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The Christmas Lectures through time

Michael Faraday was an English physicist and one of the most important scientists in history, despite his little formal education (Chisholm, 1911). Faraday developed the Christmas Lectures for children, at a time when organised learning for children was I short supply (James, 2002); in 1825 John Millington hosted the debut Lecture (Ri online, 2019). Faraday left school at 13 but was always committed to introducing science to young people. He envisioned the Lectures to be an informal affair, his lectures notes from 1827 state that the Lectures were 'agreeable – easy – where members have the privilege of bringing friends and where all may feel at ease … relieved from all formality' (James, 2002). Faraday was very successful at communicating scientific concepts and knowledge and was extremely able at persuading other scientists to do the same. He has inspired generations with the notion that communicating science to a wide audience is something fundamental for the scientific community (James, 2002).

The core principle of the Lectures has stayed the same over the decades: each year a lecturer presents a topic in front of an audience of schoolchildren. It relies heavily on over-the-top props and exciting interactive demonstrations, with the aim of getting young people excited about science.

Changing and evolving: the Lectures today

In the UK, the Christmas Lectures are still seen as synonymous with the festive season and access to the live Lectures, now as then, is granted almost exclusively to Ri members and their guests (James, 2002). The live show is the pinnacle of long months of work at the Ri. The topic and Lecturer are picked between January and March in the year of the Lecture; however the Ri are working to get to the position where the topic and Lecturer are chosen in the preceding year (Ri, 2021 personal communication). For each lecture, key demonstrations are developed, prepared and tested, including using complex apparatus and creating all the props. From development stage to the lecture itself, the event involves a vast team of educators, technical supporters, producers and film crew.

Traditionally, the Lecturer has always been picked by a committee, formally the Managers of the Ri and then the Council with input for the Director/Davy Faraday Research Laboratory staff. This changed in the 1980s when the Lecturer was picked by a committee of relevant parties including Ri Council/Director as well as BBC representatives. This occurred until early 2000s when it just became a committee of relevant people with a vested interest; this is usually the Ri, the BBC and the production company (Ri personal communication, 2021).

The world had to wait 169 years to watch the first woman presenting the Lectures and in 1994 neuroscientist Susan Greenfield presented a Lecture series (Ri online, 2018). In 2018, for the first time in their 194 year history, the Lectures were co-presented. Until then, each Lecture had only one Lecturer, but in 2018 it also included a Guest Lecturer. Professor Alice Roberts was the Christmas Lecturer, joined by Guest Lecturer Professor Aoife McLysaght. The idea of co-presenters has continued and in 2020 there were three presenters; two women scientists (Dr Helen Czersky and Dr Tara Shine) and the first scientist from a Black, Asian or Minority Ethnic (BAME) background (Professor Chris Jackson). The Ri has publicly stated that it aims to widen representations of scientists to show greater diversity in science, particularly following the Black Lives Matters protests (Ri, 2020).

Audiences for leisure-time science activities

Many countries are currently seeing populist push-back against 'experts' and the 'global elite', whereby culturally educated pursuits are largely separate from the perceived 'norms' in society (Calhoun, 2016). Despite a growing science communication movement to weave scientific concepts within everyday culture (Wellcome Trust, 2016; Wilkinson & Sardo, 2013), science free-choice

leisure-time pursuits still tend to be perceived as a niche interest for people who identify with science.

Social identity is the portion of an individual's self-concept derived from perceived membership in a relevant social group; as described in Social Identity Theory (Tajfel, 1974). Free-choice learning about science could be described as part of this audience's self-concept – a construction of beliefs and meanings about the sort of person the individual perceives themselves to be (Archer et al., 2010). Constructing a STEM identity requires three components according to Carlone and Johnson (2007); an individual must be competent at STEM pursuits, they need to perform in some way to others and they need to receive recognition for this engagement.

This STEM identity may form through being a scientist or engineer, or through being a 'science enthusiast'. Identity performance and recognition (Carlone & Johnson, 2007) is found through work or leisure-time pursuits, such as attending and/or discussing science events or centres, or viewing science-related material in the media. Social discussions on these topics provide a form of exchange value for these audience members, as described in Bourdieu's theory of Social Capital (Bourdieu, 1987). Here, the effective functioning of social groups occurs through interpersonal relationships, a shared sense of identity and shared norms and values. This has been further developed into the theory of Science Capital, whereby people who have high knowledge, understanding and attitudes to science have high science capital (Archer et al., 2015).

Research into science festivals (Bultitude, 2014; Fogg-Rogers et al., 2015; Kennedy et al., 2018) and science centres/museums (Dawson, 2014a; McCallie et al., 2009) indicates that audience members tend to be highly educated, from a white ethnicity, and have the social capital to behave as expected in these contexts. These environments can be perceived as exclusionary by people who are not from these backgrounds (Dawson, 2014b, 2018), namely from BAME groups, or with lower socioeconomic status.

Television offers an opportunity to reach beyond those who have high science capital (Dhingra, 2006; Miller et al., 2006), with research indicating that television shows and news are still the main way most Europeans receive science news (Standard Eurobarometer, 2014). A 2014 survey (adults; UK) found that TV is one of people's two most regular sources of information on science (Ipsos MORI, 2014).

Modern viewing habits

Viewing habits are changing very quickly in relation to television and other video content. Ofcom's Media nations report from 2019 reported that the amount of time people watched traditional television in the UK was falling and being replaced by time spent watching online video. This general trend was a lot stronger for younger viewers, with the number of minutes spent watching traditional television halving between 2010 and 2018 for viewers between 16 and 24. Young adults (16–34) spend over an hour on YouTube per day, and half of 8–15 year olds prefer to watch YouTube content than traditional television (Ofcom, 2019). Awareness of this shift away from traditional television by younger audiences has informed some of the BBC's more recent strategic choices.

This does not necessarily mean that all content aimed at young people needs to move online; as people view content on different platforms in relation to different needs. De Lara et al. (2017) conducted an analysis on the reception of videos about climate change published online and found that the videos produced specifically for internet viewing received more views and comments than those produced primarily for broadcast on television. This shows that a different style of material is successful on the internet, indicating that uploading televised material after broadcast is not necessarily satisfying the need that people have when seeking material online.

While there is some concern that online videos are not trustworthy (Peer & Ksiazek, 2011), content that is authentic and user-generated is more popular, this runs contrary to most scientific videos being professionally generated with high production values (Welbourne & Grant, 2016). These findings suggest that audiences prefer to watch videos by people they can relate to, rather

than the scripted scientists we often see in professionally generated content. Furthermore, a study by Sugimoto et al. (2013) found that online audiences preferred TED talks (Technology, Entertainment and Design, 2020) by academics in comparison to other speakers, suggesting that academics are the authentic voices of scientific content. Research on the science-related television watched by young people has found that male scientists are significantly over-represented across different types of shows (Whitelegg et al., 2008).

This trend of domination by men in science-related content is far from an issue only with television. Amarasekara and Grant (2019) found that among the 391 most popular science-themed YouTube channels, only 32 of these had a host who was a woman. Welbourne and Grant (2016) also found this underrepresentation of women in science-themed YouTube videos, but did not find that the gender of the presenter affected the popularity of the video. However, the presence of women can affect the comments found under science-related YouTube videos. Amarasekara and Grant (2019) found that channels hosted by women were more likely to attract comments, and the comments were more likely to be hostile, critical/negative and sexist or sexual. Tsou et al. (2014) did a similar study, but specifically analysing TED talks. They found that videos of presentations by women had comments that were more polarised, more personal, and more emotional. Together, these findings suggest that while the amount of scientific content on YouTube is growing and becoming more popular, it may not be an inclusive environment for everyone.

In summary, younger audiences are spending less time viewing traditional television and more time viewing online content. A driving force for this trend may be derived from the younger audience having a need to feel connected and able to interact (e.g. via comments), even though this interaction sometimes creates non-inclusive environments. This would explain the success of user-generated science content online (Welbourne & Grant, 2016). Connectivity and sociability are values important to young people and younger audiences (16–24-year olds) are also much more likely to watch traditional television alongside others, rather than alone (62% in 2018). Ofcom (2019) hypothesise that this may be because their solo viewing is done with online content.

Research aims

Little research has been conducted about the types of audiences who currently watch the Christmas Lectures, either on television or online (Ri, 2019 personal communication). However, as the format has to be sought out through specialist channels, we can assume that these viewers are already interested in science, or are highly educated. This paper explores the characteristics of the audiences for the current Christmas Lecture offerings, and how these engagements are perceived by their audiences.

Methods

In 2018, the topic of the Christmas Lectures was 'Who am I?' with Christmas Lecturer Professor Alice Roberts[1] and Genetics Society Guest Lecturer Professor Aoife McLysaght.[2] It was the first time the Lectures were presented by a Lecturer and a Guest Lecturer.

This section outlines the methodology used to generate the data. A variety of methods were selected; tailored to the specific events and aiming to capture the experiences of the participants involved and to assess, as far as possible, the impact of the Ri activities on participants. The evaluation methodology received full ethical approval from the Research Ethics Committee of the University of the West of England Bristol (UWE Bristol).

Semi-structured interviews with attendees (children)

Interviews with those who attended live filming offered direct access to audience members' observations and insights (Tong et al., 2007). Subjects were recruited through an article in the Ri

newsletter plus a Ri general email to parents/guardians who had bought tickets, asking them to nominate their children. The interview schedule was designed as semi-structured and included open-ended questions allowing participants to answer in their own terms (Groves et al., 2004). The questions explored the children' experiences of the Lectures, as well as their general interest in science.

Eight in-depth interviews were conducted over the phone or by Skype (by Dr Sardo); they were audio recorded and transcribed verbatim by professional transcribers. The data was analysed by hand using the process of thematic analysis (Braun & Clarke, 2006), searching for themes that captured patterned meaning across the data. The codes were then refined and accumulated into themes that represented the semantic meaning across the dataset. Secondary analysis was performed with review by the co-authors to ensure the themes adequately represented the original data.

Feedback cards and structured observations

The evaluators attended the three live Lectures and used evaluation tools that did not disrupt the flow of the event, such as feedback cards and structured observations (Grand & Sardo, 2017). Full methods are available in the Ri Evaluation Report (Sardo et al., 2019). Cards were designed to be clear and take little time to fill in.

Across the three filming days, 863 cards were distributed. A total of 257 cards (29.8% return rate) were filled in by the audience, containing individual feedback keywords as well as longer comments. The words were ranked and analysed by percentage frequency.

Social media analysis

The advanced search engine on Twitter was used to create a dataset of tweets. Results were filtered by date (between 1 December 2018 and 31 January 2019) and keywords: the hashtag '#xmaslectures' or the key phrase 'Christmas Lectures'. A total of 1718 tweets (excluding retweets) used #xmaslectures in this period, and 1122 used #ChristmasLectures in the same period, though a lot of these will be duplicates. Tweets were excluded if they were authored by the Ri, or by known employees of the Ri, the presenters and affiliated organisations and science communicators. This information was established through the self-identifying information in the twitter bios of those tweeting. This exclusion ensured the dataset was relevant to insight from the viewing public.

The analysis took a combination of both deductive and inductive thematic analysis. Inclusion was done with a deductive approach, whereby tweets were included that gave insight into specific areas of interest for the evaluation: who was watching; why they were watching; and how they were watching, as well as specific items of constructive positive and negative feedback. Tweets that met this inclusion criteria were analysed inductively to derive the final themes (Braun & Clarke, 2006).

Online surveys

An online survey aimed to reach people who are enthusiastic about science but who had not necessarily regularly or previously watched the Lectures. The online survey was designed to be short and quick to complete and included both closed and open-ended questions to encourage honest responses (Couper et al., 2002; Groves et al., 2004).

The survey included a variety of types of questions about the participants' engagement with science, TV, and the Christmas Lectures. Respondents could select more than one option, so percentages do not always add up to 100%. The survey was set up online using the platform Online Survey and it was publicised on the Ri Twitter and the evaluators' Twitter accounts from September 2018 – January 2019, as well as LinkedIn and the mailing list PsciCom. The survey was adapted for UWE Bristol students and emailed out to undergraduates.

Descriptive statistics were used to analyse the closed questions. The open comments were analysed in Excel 2016 using a content analysis, with inductively generated codes and a count of the frequency whereby the codes appeared (Bengtssen, 2016).

Results

How the Lectures are perceived by live audiences

Across the three filming days, high levels of participant engagement were observed and that level remained high well into two-thirds of all of the Lectures time. It appeared easy to engage audience members with the Lectures; they were keen to participate and enthusiastically volunteered whenever there was a call for volunteers. Interviews with attendees of the filming confirmed that; interviewees described the excitement of attending a live show and how much they had taken in from the event. Taking part in the filming of the Lectures was largely an extremely positive and exciting experience. Of the 257 feedback cards received, 254 (99%) were at least partially positive and the vast majority of words listed were very positive. More than a third of respondents wrote 'interesting' ($N = 95$; 37%) and 'fun' ($N = 94$; 37%). Other popular words were 'amazing' ($N = 52$; 20%) and 'exciting' ($N = 39$; 15%).

Young people interviewed were also very positive about their experience of attending the filming of the Lectures, specifically naming their favourite parts, and enthusing about the whole experience. The live demos were highly praised, with interviewees describing how they loved watching the experiments and demonstrations that the presenters showcased. These added richness, value, and interest to the Lectures and made sure the young people remained engaged. The statements by the interviewees are supported by observations during the filming, as well as feedback cards collected after the filming, where attendees stressed how they enjoyed the interactive element of the Lectures.

One aspect that sets attending the filming apart from watching the Lectures on TV or online is the call for action and opportunities for audience participation. The majority of interviewees mentioned it and 'interactive' was the fifth most used word on feedback cards ($N = 25$; 10%), with many of the longer comments centred around audience participation. A considerable amount of young people requested more audience participation:

> I like going there and knowing that I could be one of those kids that's on TV doing all the cool experiments. (Interviewee 2018-03)

Even when children are not chosen to help with the demonstrations, they enjoyed seeing their peers participate.

Not being picked can lead to some frustration and it was mentioned by a few interviewees, who pointed out that those sitting at the front have more chances to be picked to participate. It is difficult to manage such high expectations of being picked to go on stage, as only a small number of attendees get the chance to participate. Nevertheless, the opportunity for audience participation is no doubt one of the elements that makes the experience of attending the filming very different from that of watching the broadcast of the Lectures.

Interestingly, emotive presenters with excellent communication skills were mentioned by the audience as one of the highlights of watching the filming of the Lectures, with some interviewees saying the presenters were their favourite part of attending the event and other attendees leaving specific comments about it:

> They communicated and worked with the audience. Good at expressing emotion. (Feedback card)

Another aspect that sets attending the filming apart from watching the broadcast is that the children have the opportunity to understand how a TV programme is made. There were lots of comments, both during the interviews and on the feedback cards about the excitement of attending a live TV

show, with cameras, crew etc., and being able to grasp how a TV programme is made. However, the filming experience can also be a slightly frustrating one for children. Attendees understood reshooting scenes is part of attending the filming of a TV show but some mentioned it as one of the least favourite parts. One interviewee however, acknowledged that albeit tedious, it was useful to watch some scenes more than once.

> Not boring exactly, just a little bit frustrating but it was useful to re-remember and recap. (Interviewee 2018-02).

Reshooting scenes, queuing to get in and just generally waiting were the least favourite parts of taking part in the filming of the Lectures, although young people acknowledged it is not specifically part of the filming.

Physically being at the Ri headquarters is another aspect that makes attending the filming a different, more exciting and richer experience than watching the broadcast, on TV or online. Words such as 'cool' and 'exciting' were used to describe the experience of being in that particular venue. Some participants showed a great understanding of the importance of the Ri:

> I know I'm going there to learn about science which I love and also it just feels like a really special place to be for scientific achievement in the UK. (Interviewee 2018-03)

While the Lectures are aimed at children aged 11–17 years old, some content, or the way it is communicated, might lead to the perception that the Lectures are not appropriate for older audiences. A small number ($N = 4$) of feedback cards included comments indicating that, although still enjoyable, perhaps the content was not tailored for a slightly older audience.

Attitudes towards science after attending the filming of the Lectures

Attendees were asked if attending the filming had changed the way they felt about science. The answers were all overwhelmingly positive, from enjoying science more to producing better school work. Although we recognise our qualitative interview sample is small ($N = 8$), it gives us great clues about the potential effect that attending such a high profile science event might have on attitudes and behaviours towards science. Five interviewees (62%) said that they connected more with science at school, after attending the filming of the Lectures. One child has since joined the science club at school and another joined the dissection club, while others reported higher levels of engagement or new interests following the Lectures:

> It's really opened up my understanding of Evolution. I've never really known that much about Evolution past Darwin's basic theories. (Interviewee 2018-03)

Finally, attending the filming gave the attendees an excellent opportunity to have a glimpse into the complexity of science. Interviewees described having a better understanding of how complex science is and that there is just now one right answer or absolute knowledge:

> It's become even more interesting, there's no simple thing that's right or wrong, there's always more you're going to find out and you can always have a deeper knowledge of something. (Interviewee 2018-07)

Asked how they connected with science since attending the filming, only two attendees stated they did not connect with science in any new ways since attending the event. All other children mentioned they engaged with science in different ways, including being more interested in it at school, buying science magazines, and attending science related events, such as Family Fun Days.

Broadcast: how the Lectures are perceived by audiences watching on TV/online

A total of 1718 tweets (excluding retweets) used the #xmaslectures hashtag in the analysed period, and 1122 used 'Christmas Lectures' in the same period, though a lot of these will be duplicates using both. Several prominent themes were evident in the social media analysis that related to who was

watching (including audience age, class and gender), why they were watching (including tradition and presenters); and how they were watching.

The vast majority of tweets (65%) over the two-month sample happened during the three-day period where the Lectures were broadcast (26–28 December 2018), and mostly during the broadcast time; this indicates that many people were watching as the Lectures were live on television. However, there were also people tweeting to report they had just 'caught up' with the Lectures on BBC iPlayer.

There was evidence on Twitter of families watching together, both with children and without. There was evidence of children engaging all the way from age 5 to late teens. In the sample, nearly every mention of a child was accompanied by their age (Table 1). There may be varying motivations for this; it is perhaps indicative of parents wanting to illustrate some point about the studiousness of their child, or alternatively to illustrate the wide range of children watching. These motivations should be kept in mind when interpreting this data.

There were many comments from adults watching, with these tweeters often showing that they were aware they were engaging with something they perceived as being meant for children (see Table 1). Many comments indicated that people felt that the Lectures were accessible while not dumbing down the material, making them appeal to 'all ages'.

There are other perceptions around who the Lectures are for, including issues of social class. Only two tweets mentioned class (Table 1), but both seemed to indicate a historical or lingering perception that the Lectures were for middle class audiences. There was also a lot of commentary focusing on gender, as historically, the Lectures have been dominated by male scientists. Many comments focused on the scientists being good representations of scientists and role models for those watching, especially young girls.

One of the main themes for those tweeting about why they were watching the Lectures was tradition and the habit of doing so every year. Tweets mentioned having traditions from childhood, and parents passing on the tradition to their children. There was also some indication

Table 1. Summary of Twitter analysis on who was watching.

Theme	Example quotes
Children viewing (with family)	'My kids (5&7) enthralled by parts 1&2 #xmaslectures is a masterclass in joyful #STEM learning'. 'I loved tonight's lecture, really looking forward to the next 2 – my son (16) was absolutely riveted, even put his iPad down!! #xmaslectures'
Adults watching with an awareness that the lectures are meant for a younger audience.	'I'm not the target audience but I've been watching for over 40 years and this year's with @theAliceRoberts make me wish I was young enough to be starting to choose an education, a career'.
Suitable for all ages	'Personally felt this year's awesome #xmaslectures were engaging for most ages (not always the case). An excellent balance of science, fun, explanation and an enthusiasm for the subject'.
Class	'I didn't start watching the Christmas Lectures till my mid thirties as I was a council house child and didn't know they existed! Hope that has now changed and it is reaching a wider audience'. 'I really do enjoy the Royal Institution Christmas Lectures … sadly the audience is always so representative of middle class privileged children, not a realistic representation of society!'
Gender	'.@aoifemcl and @theAliceRoberts smashing the #XmasLectures. Like @sophiescott before them, they show youngsters that a Professor looks nothing like the stereotypical old white dude. '
Tradition	'Christmas wouldn't be Christmas without the Royal Institution lectures. Quite different from my childhood with the likes of Prof. Eric Laithwaite and Heinz Wolff but just as entertaining and educating' 'I've been watching the #xmaslectures with my Father for 50 years and we both think that the 2018 Lectures with @theAliceRoberts and aoifemcl rank among the very best. Fun, thought provoking and not afraid to tackle important issues. Fantastic'.

that the Lectures in 2018 had changed sufficiently to attract those who would not typically tune in:

> I remember watching the @Ri_Science #xmaslectures as a kid and always loves them. I stopped watching them around 15 years ago as, for me, they lost their edge. Thank you @theAliceRoberts and @aoifemcl for restoring my interest in these lectures! (Twitter)

What do self-identifying science enthusiasts think of the Christmas Lectures?

In total, 420 people completed the online survey for science enthusiasts (46%M:45%F). The main survey (non-student specific) was completed by 354 participants, of whom 52% identified as male and 46% identified as female. Most of the sample (75%) had studied and/or worked in a STEM related career. However, 25% of the sample said that they were just interested in STEM topics. The ages of participants ranged from 18 to 75+ with the mode age category being 35–44 years old.

In addition, 66 students completed the university survey (59%M:41%F). Most of the participants were from a Physical Sciences or Engineering background (68%) while 32% were from a Health Sciences background. The participants were mainly aged 18–24 years old (80%).

Leisure-time STEM activities

The majority of respondents reported watching science documentaries on TV in their leisure time; 90% of general respondents and 83% of student respondents. The next most popular activity for the older general survey respondents was visiting science centres or museums (80%), while student respondents' next-preferred option was following science social media outlets (68%). However, general survey respondents also reported following social media as well (70%). There was a large difference in engagement with public lectures and events, with 60% of older respondents reporting this activity, whilst only 26% of students did the same. The other activities were similar in profiles of engagement (Figure 1).

Both the general respondents (96% of sample) and the student survey respondents (95% of sample) indicated that the main thing they liked about engaging in STEM activities in their leisure time was learning about new things, as well as re-engaging their interest in science (58% general; 59% students). General survey respondents were twice as likely to report enjoying igniting interest for other people in science (49% general compared to 27% students), as well as meeting/chatting to

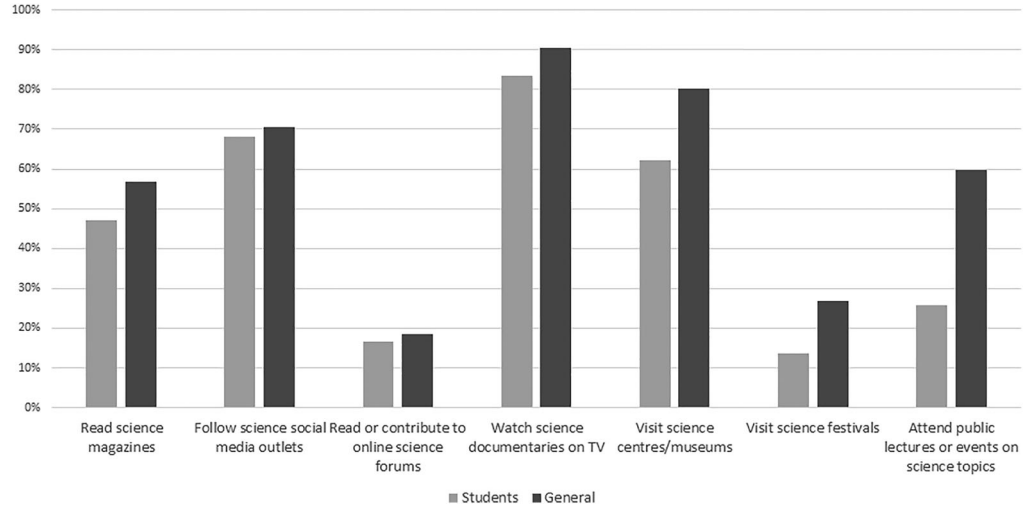

Figure 1. Leisure-time STEM related activities.

other people (37%:18%) or scientists (34%:23%) which may reflect their older age profile. Other reasons are shown in Figure 2.

The most reported method for watching TV for the general survey, with an older age profile, was live (76%) or on demand (76%) through a television. Students however, were more likely to report that they watched videos through short clips on social media (80%). Whilst the general survey respondents also watched social media videos (63%), students were much less likely to watch live TV on a television (53%). They did however, watch videos on demand through a television (74%) or tablet (74%).

Science enthusiasts' perception of the Christmas Lectures

In total, 48% of all 420 people surveyed watched the Lectures every year, while 25% watched when the subject interested them. However, this clearly varies hugely across age demographics, with only 27% of the student respondents having reported watching the Lectures at all, while 73% had never seen them. In the general survey with a much older age profile, 56% reported watching the Lectures every year, and only 8% had never seen them.

General respondents who had watched the Lectures were more likely to watch them live on TV (69%) or after broadcast on BBC iPlayer (71%). Of the 27% of student respondents who had seen the Lectures, the main way of watching them was in short clips on YouTube (72%) (Figure 3).

Respondents who had seen the Lectures mostly reported that they watched them on their own, in both the general survey (54%) and the student survey (83%). However, respondents also indicated that the Lectures were family viewing, with 33% of students watching with their parents, and general respondents viewing with their spouse (39%) and/or children (24%).

Respondents who had not watched the Lectures were asked why they had not done so, given their interest in science leisure activities. All of the students who had previously not watched the Lectures (73% of the survey respondents) were not aware they existed. Indeed, 61% of those student respondents did not know what age group the Lectures were aimed at, while 50% guessed that they were aimed at 16+ year olds.

Amongst the general survey respondents, 44% indicated that they were not aware the Lectures existed. The remaining respondents indicated that they do not have time to watch television (26%),

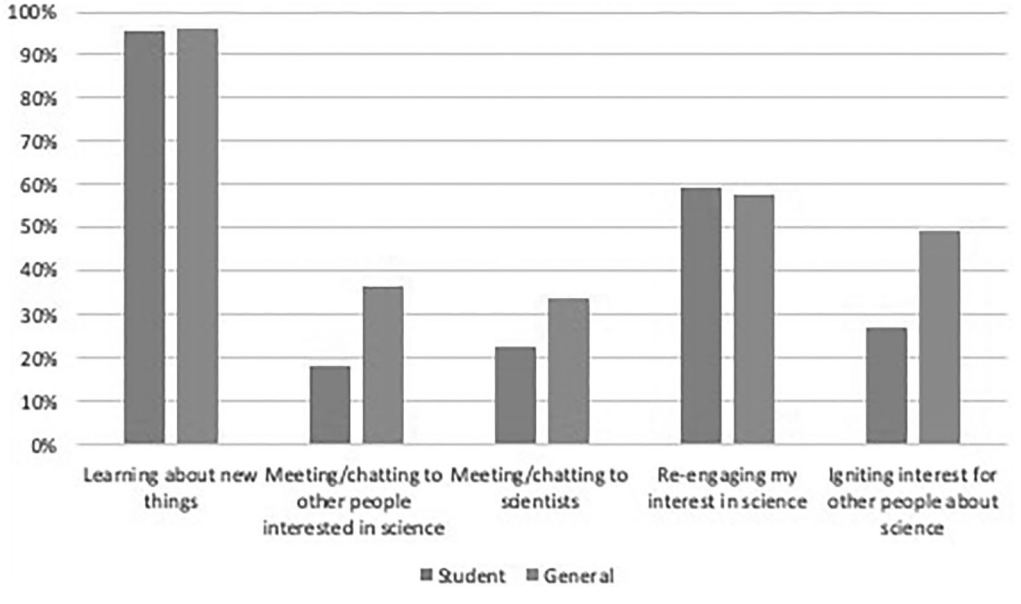

Figure 2. Reported benefits of leisure-time STEM related activities.

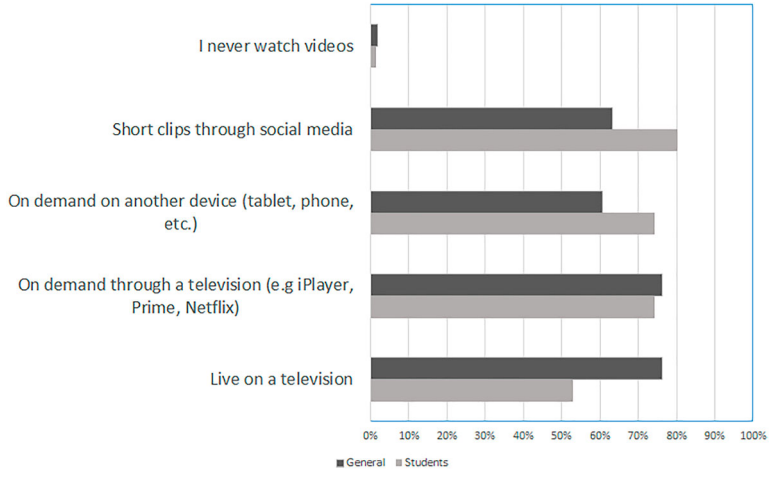

Figure 3. Method of watching the Lectures.

they do not have time to watch a long programme (22%), or that they feel the Lectures are not aimed at them/the topics don't interest them (26%).

Improving the Christmas lectures

Respondents who had watched the Lectures were asked how they would improve them, while participants who had not watched them were asked what would encourage them to do so. The qualitative data were analysed using a content analysis (with quantitative summary for comparison), giving rise to the themes in Table 2. In general, participants thought the Lectures could be improved with more advertising as well as shorter clips to share on social media. Whilst the Lectures are described as being aimed at young people, the length of the Lectures was deemed too long for modern younger audiences, and being broadcast on a TV channel which does not appeal to young people. To enhance the broad audience experience, some also suggested including separate lectures, or extension material, aimed at adults and tackling current issues through ending with open questions to illustrate how science works.

Discussion

The Christmas Lectures series is the continuation of a 196 year old tradition, and yet to this day, they remain a centrepiece of the science communication landscape. As demonstrated in this paper, people who are enthusiastic about engaging with science as a leisure-time activity (whom we call 'science enthusiasts') want to watch the Lectures, talk about them, and discuss them face-to-face and online. However, the Lectures may not be reaching a broad audience of young people (their intended target), due to the channel and format/timing of their broadcast. In this Discussion we explore the value of the Lectures for science enthusiasts, as well as how the Lectures' reach could be extended if needed.

Performative and recognition activity for identity reinforcement

For those who regularly watch them, the Lectures are viewed as an institution with strong traditional importance, providing exchange value to enhance cultural capital (Bourdieu, 1987). This was intimated in the children's interviews, the Twitter analysis, and the science enthusiasts' survey. Indeed, knowledge of the Lectures and discussing them with others could be seen as synonymous with high science capital (Archer et al., 2015). For those engaging and encouraging their family to engage (39% of survey respondents), it seems that viewing the Lectures forms part of their STEM

Table 2. Summary of content analysis for comments about improving the Lectures.

Theme	Percentage of responses	Example quotes
Too broad for all audiences	26% ($N = 90$)	'They've been dumbed down to the point that as a holder of 2 science degrees I now find them more frustrating than engaging. Why do all science programs on TV now need to go for mass appeal and make the assumption that the audience knows nothing about the subject?' Male, 45–54 years
Live lectures vs the needs of television	22% ($N = 78$)	'A 'lecture' is always going to be of limited appeal. The format is carried on tradition and location and not on the most effective means of communication. If the Lectures are to be primarily designed to target the audience not in the room then they need to be produced with that in mind. No modern media uses an hour-long lecture format for mass entertainment/education. They can throw in as many explosions or elephants' toothpastes as they like but the format will always limit the audience. Format or audience. They get to prioritise one'. Male, 25–34 years
Changing TV viewing habits	13% ($N = 46$)	'Move them away from BBC4 to a channel that kids actually watch, maybe even Netflix?' Female, 25–34 years 'More freely available. Not always easy to find and also edited into smaller clips that can be used on social media and in education'. Female, 45–54 years
Wider advertising	13% ($N = 45$)	'The content is great but even as an interested audience I sometimes forget about them so I'd like to see better/more advertising – to a range of audiences'. Female, 18–24 years
Story with relevance to modern issues	12% ($N = 43$)	'They tend to lack storytelling and narrative and become a series of experiments which often can't match the exciting nature of the kind of external/pre-recorded video inserts audiences are now used to'. Female, 45–54 years
Passionate presenters	9% ($N = 31$)	'The Lecturers were the finest of the last 5–6 years as I have been watching the Lectures. You need two lecturers representing our diversity as a species. Women, folks of colour, millennials and seniors with gusto. All scientists. Perhaps the Two Professors were so successful as they both were public presenters of STEAM'. Male, 55–65 years

identity; providing both a performative and recognition activity to reinforce their social identity as science enthusiasts (Carlone & Johnson, 2007).

The Twitter analysis reinforced this idea of performative and recognition activity; people watching the Christmas Lectures and who had a Twitter profile wanted others to know that they were watching that year's performance on TV. By tweeting about the lectures, they were performing an aspect of their STEM identity; indicating their opinions on the lectures, or sharing their knowledge of the topic or previous year's performances. They also often talked about their family in the tweets, perhaps to indicate their shared family identity or high cultural/science capital (Archer et al., 2015).

Data from the Twitter feed reinforces that the Lectures are still relevant and perceived as high quality and valued content. This data indicates that, for that specific audience, the Christmas Lectures do not need to change, and they chime well with science enthusiasts. Twitter, as with other social media, is often a method for people to broadcast identity-defining information about themselves or their children. As such, the feedback garnered from the social media analysis should be interpreted with this in mind. Many viewers whose identity is less bound to an association with the Lectures and the Ri may not choose to broadcast their experience of the Lectures on a public platform.

Performative activity to reinforce social identity or high cultural capital can have the opposite effect for those who do not have high science capital or who do not form part of that 'in group' (Tajfel, 1974). People from lower socio-economic groups, or who do not have friends or family with knowledge of scientific study, may be put off taking part in exchanges where they do not know the correct jargon or cultural norms. This has been shown to be the case in science centres and museums, where the cultural contexts are perceived as exclusionary by people from working class or BAME backgrounds (Dawson, 2014b, 2018).

Children who were invited to participate in the live Lectures indicated that they did not find the experience to be exclusionary. The most popular words on the feedback cards were 'interesting, fun,

amazing, and exciting', with almost no negative words. Interviews with participants also indicated that the children found the experience to be very welcoming and insightful, with many stating that they had a higher interest in science after the experience. While the majority of live lecture tickets are allocated to Ri members (who we could assume have high science capital), a proportion are allocated to local schools from lower socio-economic areas. This may be something that the Ri could enhance in future years to promote inclusion in the live lectures and to celebrate the diversity of the audience for the TV production.

Reach of the Lectures via television

One of the most popular ways that UK adults receive scientific news is through television (Ipsos MORI, 2014), and so this medium offers an opportunity to reach beyond people who have high science capital (Dhingra, 2006; Miller et al., 2006).

In the main science enthusiast survey from our research, only 8% of participants had never heard of the Christmas Lectures, while 56% watched them regularly. This self-selected sample ($N = 354$) had an older age demographic (modal age category 35–44 years old) with a mostly professional background, with 75% stating that they had studied and/or worked in a STEM related career. As such, knowledge and interest in the Lectures was high, and was reinforced by 90% of participants also watching science documentaries on TV and 60% also attending physical science lectures/events. General respondents who watched the Lectures were tended to watch them live on TV (69%) or after broadcast on BBC iPlayer (71%)

In contrast, 73% of the student science enthusiast sample ($N = 66$) had never watched the Lectures, and only 26% attended other science lectures or events in their leisure time. Of the 27% of student respondents who had seen the Lectures, the main way of watching them was in short clips on YouTube (72%). These statistics were also echoed in their self-reported means of watching wider TV, with most stating that they watch videos through short clips on social media (80%), or on demand (74%). This sample had a much younger demographic, with a modal age category of 18–24 years and studying STEM as a first degree. Socio-economic status may also play a role in awareness of the Lectures, as the students attended a post-92 university, which tend to attract people from lower middle-class or working class demographics.

These findings reinforce wider cultural data showing that younger audiences are spending less time viewing traditional television and more time viewing online content (Ofcom, 2019). These changes are in contrast with the stated aims for the audience of the Christmas Lectures (young people) and the current media platforms the lectures are broadcast on (BBC FOUR, reaching an older educated audience at 8pm). This channel/medium is clearly not congruent with young people 'accidently' watching the Lectures via a platform they would ordinarily watch, which is a key aspect of expanding science capital (Archer et al., 2015). Indeed, of the 73% of students who had not watched the Lectures previously, all of them (100%) were not aware they existed. Furthermore, 50% of those students guessed that they were aimed at 16+ year olds and not their intended target audience, which indicates they would not be appealing to expand the science knowledge and awareness for this group.

While the Lectures have clearly developed over the years, in particular improving their diversity of presenters (featuring women and people from BAME backgrounds), they remain in a traditional hour-long lecture format with visual demonstrations. While this is interactive and enjoyable for people attending in the audience, this is now a difficult format to compete with more popular online science shows or demonstrations. These videos tend to be shorter (1–5 min), allow for online comments and chatting, and make the most of the video format with animations or graphics to explain key science concepts. This was also noted by participants in the online surveys:

> "They can throw in as many explosions or elephants' toothpastes as they like but the format will always limit the audience. Format or audience. They have to prioritise one." Survey respondent, Male 25–34 years

Conclusion

The Ri Christmas Lectures are a much loved event, with audience members keen to attend in person, and children coveting the prize of appearing on stage. For the children who attend, our interviews indicate that the Lectures enhance attitudes and interest in science at school. These opportunities are very valuable, and need to be carefully distributed to ensure diversity in the children who attend. This also helps to enhance inclusion in the filmed video materials, by role modelling diverse audience members, as well as diverse presenters.

The current broadcast format of the Lectures is also beloved by people with high science capital, who are keen to affirm their STEM identity by connecting with others in the same social group. The Twitter analysis indicates that the Lectures are seen as a traditional part of the festive season by many science enthusiasts, and form part of the established calendar of science social events. The Lectures' exciting science experiments and connections to modern day scientific issues are highly praised and valued by science enthusiasts.

While the Lectures themselves may not need changing, the broadcast Lectures as a vehicle to reach young people, or to enhance science capital for non-science enthusiasts, may have to be further thought through. Younger audiences are spending less time viewing traditional television and more time viewing online content, which tends to be shorter and enable interactive online conversations. If the Ri wishes to extend the reach of its audience for the Lectures, the broadcast format may need to change to feature on channels or media which younger non-science enthusiasts are more likely to watch.

However, it is only the stated aims and the broadcast format which are out of step. The Lectures themselves are much lauded, and the current audience has affirmed via Twitter and surveys that the Lectures are highly praised for entertainment and education purposes. Science communication aimed at STEM enthusiasts plays a valued role as a performative and recognition activity to enhance STEM identity; much as classical music events do for musicians and art shows do for art lovers. If the aims were re-adjusted then it would be much clearer that the Lectures are a celebration of science within society, and play a key role as a traditional cultural event for science enthusiasts.

Notes

1. https://www.birmingham.ac.uk/staff/profiles/biosciences/roberts-alice.aspx.
2. http://www.gen.tcd.ie/molevol/.

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