Invincible
Evaluation Report

Mireia Bes i Garcia, Ellie Cripps, Vivienne Kuh, Kate Miller, David Owen, Alison Rivett, Kathleen Sedgley and Diane Thorne

Summary

"I was intrigued, challenged & entirely engaged." *Audience member, Invincible 2017*

Invincible is an immersive play exploring the personal and societal issues surrounding the emerging science of Synthetic Biology. The fundamental aspect of this project is three-way engagement between artists, researchers and audiences. It is a product of close collaboration between Synthetic Biology researchers and artists from Kilter theatre company, supported by the Public Engagement Team at the University of Bristol. Staged in a real residential flat, the intimate and interactive performance puts each member of the small audience into the heart of the play. They are invited to consider the benefits and risks of the science, as well as the moral and ethical implications of this developing research field.

The first performance run of 23 shows in Spring 2017 was evaluated by an independent evaluator using a mixed-methods approach comprising audience, researcher & artist surveys, observations and a post-project workshop. Almost 350 people saw the play, comprising roughly equal numbers of Year 9 & 10 school pupils and their teachers; invited guests e.g. researchers, arts professionals, youth leaders, university students etc.; and members of the public.

Overwhelmingly the outcome for all audiences was learning about Synthetic Biology, this being a topic the majority knew very little about beforehand. A significant proportion of respondents said they had been motivated to find out more afterwards. Many commented on the personal nature of the 'close-up' performance and also the novelty of how audiences' opinions were captured as an integral part of the play, although there were mixed opinions about how successful this was.

A distinctive feature of *Invincible* is its ambiguous portrayal of Synthetic Biology and the word most used to describe the audiences' experience was "*Thought-provoking*". Being neither 'for' nor 'against' provoked viewers to develop their own opinions and ethical stance. A post-show Q&A was a critical part of this and allowed the time for audience members and researchers to discuss and reflect on the ethical issues raised. For many, particularly school pupils, it was also an important opportunity to ask questions about the science and make sense of it.

For the creative team the project was also a unique chance to learn about and develop their personal views on Synthetic Biology, through prolonged interaction with scientists, which they strongly felt improved the balance and authenticity of the piece.

The experience for the scientists of working with the company was especially positive. For them a particularly important outcome was that the science was accurately portrayed, and their input was genuinely taken on board. The process also gave researchers a rare chance to consider the implications of their research more deeply. In many cases they reported learning new skills and ways to engage the public. Interacting with audiences was also beneficial, with most saying that the discussions and feedback would influence their research to some extent in the future.

The success of this project in producing a quality piece of theatre based on robust science surpassed many expectations. It is an enlightening example of how a collaborative and reflective artistic approach can lead to profound outcomes in both the understanding of, and dialogue around a complex and emerging field of scientific research.

1. Introduction

Invincible was a participatory theatre production produced by Kilter in partnership with researchers from BrisSynBio[1] and the Public Engagement Team at the University of Bristol. The production was funded by Synenergene, a four-year knowledge mobilisation and mutual learning programme funded by the European Commission under the 7th Framework Programme. Synenergene aimed to contribute to Responsible Research and Innovation (RRI) in Synthetic Biology by establishing an open dialogue between stakeholders concerning potential benefits and risks, and by exploring possibilities for its collaborative shaping on the basis of public participation.

Invincible was written in collaboration with the University of Bristol's play-writing fellow, David Lane, and was the result of over 12 months collaboration leading to a piece of immersive site-specific theatre. Set in a family house in 2047, each performance was opened up to audiences of no more than twenty, therefore inviting participants right into the heart of the play. The performances took place between the 21st February and the 4th March 2017 with an average of two performances a day, with the exception of Sundays.

The storyline for *Invincible* focuses on three generations of women within the same family: grandmother, Professor Lillian Simmonds, who pioneered a Synthetic Biology treatment for people with mental health issues; mother, Kate, a journalist who writes frequently on the risks of Synthetic Biology as a 'sticking plaster' for the problems faced by human-kind; and daughter, Jasmine, who at the age of 12 was given the treatment with her grandmother's consent but at 15 is considering having it removed.

Throughout the performance audiences were invited to express their views on Synthetic Biology, its risks and applications, through the use of voting cards. These views were captured by real scientists dressed in white coats, in a silent role throughout the performance. At the close of the performance after a climatic final scene, cast, crew, scientists and audience members were invited to take part in a Q&A discussion in which potential applications of the science and potential risks were frequently debated.

In coming to this final piece there were several key steps. These included:

- **Project workshops** with Synthetic Biology researchers, philosophers, public engagement specialists and theatre producers. Three workshops were held: the first to explore the potential of Synthetic Biology and its applications; the second to feedback on the first 'treatment'; and the third to feedback on the first read through of the script.
- **Site visits** where actors visited the Life Science Building and met scientists in their labs to talk about their research.
- **Open rehearsals** where scientists visited the performers and inputted into the creative process.
- **Ongoing project meetings** where specific elements of the project were discussed, including marketing, venue selection, script and school engagement.
- **Online consultation and sharing** including the sharing of resources about Synthetic Biology, detailed edits to scripts, logo design etc.

[1] *BrisSynBio is a BBSRC / EPSRC funded multi-disciplinary Research Centre in Synthetic Biology at the University of Bristol.*

In addition to these specific steps was the extensive reflective and group processes required for the development of a piece of art within the creative team themselves. For example, we know that many of the artists undertook their own research into Synthetic Biology, reflected with friends and family, and the creative team met frequently to digest, synthesise and bring to life the issues that the science raised.

There were also two opportunities for researchers to get involved in the performances themselves:

- the 'performing' scientist: a silent performance role – where dressed in white coat, the scientist would capture the audiences votes throughout each scene and run mock tests as the audience transition from scene to scene.
- the question and answer session: at the end of each performance a scientist would take part in a discussion with the audience, cast and producers.

This evaluation report draws on data collected from a number of sources including audience, researcher and artist surveys, participant observation and a project workshop to capture the outputs and outcomes arising from the project. It is intended as a resource for reflection and learning to identify key strengths, opportunities and challenges arising from the project and recommendations for next steps.

2. Methods

The following methods were used to collect data for this report. The data was collected and analysed by David Owen.

Online Surveys

At the close of the project separate surveys were sent to:

- **Participating artists and producers**: to capture what has been learnt about Synthetic Biology, how the process has been working with researchers and recommendations for improvement. (n=6)
- **Participating researchers:** to understand what has been learnt from the public, how this has influenced research, what the process has been like and areas for improvement. (n=11)
- **Audience survey:** to find out where people heard of the performance, what they learnt/took away, recommendations for improvement. (n=56)
- **Teacher survey:** to understand how they selected students to take part, motivations for taking part, emergent outcomes for the students and whether the schools resource pack was used. (n=4)

De-brief workshop

An evaluation workshop was held in the Life Sciences Building. It was attended by 19 people including representatives from each of the main project groups, with the exceptions of schools. The aim of the de-brief was to:

- Reflect on the successes and the learning that came from the project.
- Look at areas for development, including how the project engaged with schools, public audiences etc.
- Look at potential next steps and opportunities moving forward.

Participant observation

Four performances in total were attended and notes were taken on experiences and audience reactions during the performances and throughout the Q&A.

Quantitative data

Data collected includes:

- Audience and participant figures
- Social media data

3. Audience and Participant Numbers

3. 1 Audience numbers

The audience potential for *Invincible* was 460 if all performances were filled to their maximum capacity of twenty. The project reached 75% of its total capacity and a full break down is below:

Audience type		**Number**
Teachers		14
School pupils (yrs. 9 & 10)		84
Invited guests	*Approx. breakdown*	134
	Artists, performer, producer (25%)	
	PE professional (10%)	
	Researcher (9%)	
	Students (25%)	
	Other (33%) (media, youth/community worker, family, unknown)	
Public audiences		95
Dress rehearsal		17
Total	**344**	**344**

Table 1: Audience numbers

Schools

- Predominantly year 9 classes; whilst we had targeted year 10 students, schools were reluctant to take this year group out of school.
- In all but one case top performing students were selected to take part in the trip.
- All schools who took part brought a maximum 13/14 pupils as this was the capacity of their largest mini-bus.
- We were only able to fill eight of the eighteen reserved slots with schools, key challenges included:
    - Taking years 10 and 11 out of school
    - None of the afternoon slots (1:30 – 3:00 pm) were taken up
    - School policy often requires trips to be arranged up to a year in advance
    - Audience size meant that teacher supply cover was required (incurring costs)

Guests

As the project evolved we adapted to the lower take-up from schools and created a number of invite only events in the afternoon. For these we targeted several key groups including:

- Researchers and research directors working in other fields.
- Students studying drama, Synthetic Biology and science communication respectively.
- Artists and theatre makers.
- Public engagement specialists and potential funders.
- Community groups and representatives.
- People working in the media.

These groups were specifically chosen to help us further the projects aim and reach a broader audience. These events reached 85% capacity.

Public

These were by far the most popular with each of the public events sold out and 100% capacity attendance. The feedback survey (n=56) was sent to both invited guests and public audiences. From this survey we learnt that people heard about the event in the following ways:

- 48% via invitation (we assume that the bulk of these are the invited guests).
- 20% via word of mouth.
- 16% via newsletter.
- 13% via other routes (University lecturers, What's on/other university newsletters etc.).
- 2% through social media.
- 2% through radio.

We chose not to collect demographic data from audiences, aside from the schools, as no substantive attempts were made by the project team to engage audiences that might be underserved by STEM enrichment activities.

We did ask how frequently those attending *Invincible* would attend a cultural event in an average month. We found that:

- 11% attended less than once a month
- 39% around once or twice a month
- 21% between three or four times a month
- 29% more than four times a month

3.2 Participant numbers

As detailed above, this project was about three-way engagement between artists, researchers and audiences. The numbers of each involved were as follows:

Scientists	19
Actors	3
Producers/Writers	5

Table 2: Participant numbers

Taking into account their contribution towards the development of the performance and participating in the performance itself, we estimated that a researcher who was fully involved in all elements of the project could have committed up to 30 hours. In practice however, the team shared responsibilities between them, and the project coordinator and producer played a role together in keeping the group up to date with developments. A researcher on average, spent an estimated 10-15 hours on the project.

We discuss the outcomes for researchers later in this report.

3.3 Cost per audience head

Taking into account cash expenditure only, the estimated cost per audience head is £83.00. Whilst this figure may be high, it is important to consider these specific elements:

- A key element of the project which does not usually exist in traditional arts programmes was the consultative approach with researchers, therefore facilitating two-way engagement between stakeholders and working to inform research.
- The necessity for the performance to be scientifically robust and accurate, requiring greater development time and more stringent risk management approaches.
- A stipulation from the funders that we could not charge for events, thus minimising the opportunity for private income.
- The short run of the performance alongside the unique nature of the site, creating an intimate and immersed experience but for smaller audience groups.

We have also compared this figure with one other similar project using arts and public engagement with research and found it to be at a similar cost per head. However, we know that funders such as the Arts Council and British Film Institute would set targets around £10 per head. We view this finding as a consideration for the funders themselves as opposed to the project team, particularly as research funding looks to draw more extensively on artistic approaches. There is an ongoing responsibility amongst funders to draw on best practice within the arts and to drive good practice within its investments. This will help to ensure value for money and accountability towards the public for how that money is invested.

4. Key Outcomes

4.1 Outcomes for school students

- All teachers felt that all students were more informed about Synthetic Biology as a result of attending *Invincible*.
- They indicated that some of the more curious students would follow up and learn more about Synthetic Biology as a result of the performance.
- A number of teachers commented that they had overheard conversations about the performance at school into the following week, but gave no indication about what aspects of the performances were discussed.

> *"the cast and set was amazing and the students thoroughly enjoyed it – I know this as I have heard them discussing aspects around the school to other students who did not attend"*

> *"I think the performance and venue exceeded both mine and the student's expectations. It was brilliant. We learned about Synthetic Biology and some its potential uses/ethical impacts".*

- Several teachers commented on the positive benefits of encouraging students to discuss ethical questions that do not have a binary or straightforward answer. They felt this was one thing the performances did particularly well:

> *"It exceeded our expectations. The students and us really enjoyed the performance and found it really interesting and informative. When chatting to them on the bus back they all said they learnt a lot, about Synthetic Biology, its ethical and scientific implications".*

- All but one teacher felt the performance would have a positive impact on students considering science as a career. The teacher that did not feel this, felt that more support would be needed for students reflect on this as a potential for them.
- The Q&A was a positive intervention and helped make sense of the performances, giving students an opportunity to ask questions. One teacher commented that:

> *"Without it we would have left with a lot of questions, but hearing from the experts and having a chance to reflect helped our understanding, gave the students a chance to discuss and think more deeply about what we had seen".*

- Evidence collected from the creative team suggested that the older group (year 10) seemed *"utterly engaged and inspired by the experience…"* They also noted that *they "had the vocabulary and understanding to apply what they were seeing and hearing to their own studies & the wider world, political & scientific…*". In contrast the younger year 9 groups appeared "*perplexed*" at times. The suggestion follows that the performances would work well for years 12 and 13.
- Several teachers commented on the uniqueness of the venue and that it made the whole experience more memorable. For example:

> *"I don't think they've ever experienced such an up-close performance. I think they possibly found some parts a bit awkward, but that added to the overall impression as I think it was probably meant to feel awkward".*

- One teacher commented that the choice of mental health as an issue, made the performance much more relevant to their lives compared to other applications which could have been chosen.
- Every teacher said they would be interested in attending a re-run of *Invincible* and would like to work with the Public Engagement Team on future projects.

In terms of suggested improvements or developments:

- One teacher felt that the smiley face questions were too broad and that students found it difficult to pin down an exact answer. These questions generated a mixed response from public audiences and may benefit from some further refinement and testing.
- There was some evidence that more in-depth engagement with schools could be beneficial. Ideas from the team included a longer workshop exploring the science/ethics, masterclasses with Kilter about the process of producing the play, or a version of the script where all the characters are young people and the students perform aspects of it (NT Connections was suggested as a possible model: www.nationaltheatre.org.uk/learning/connections).
- We provided the schools with a resource pack. This provided basic information about *Invincible*, alongside an introduction to Synthetic Biology and two suggested exercises for classroom-based activity. The Synenergene Evaluator and teachers felt the resource was well laid out, sufficiently comprehensive and easy to access, however it was not used by any of the teachers in advance of *Invincible*. One teacher said they intended to incorporate into the GCSE topic on nanotubes and particles, another indicated that they were intending to rewrite the resources for the new KS4 syllabus and would insert certain components as they may fit.
- One teacher suggested we could have turned this resource into something that was handed to students (potentially in the form of a flyer or magazine) as they left the performance.
- All teachers were generally pleased with the prior event information provided and instructions for attending *Invincible*. The main issues reported were the parking. On some days schools had to park fifteen minutes' walk away from the venue. Unfortunately, this was a last minute change and the walk had not been included in the prior information or risk assessment that was sent to the schools.
- One teacher lamented that the performance could not be shown in school.
- If we were to target schools from areas of deprivation it may be important to consider the cast, character, setting and script for *Invincible*. *Invincible* works as a believable coherent family, script and context as it is set in a family that is rich in 'Science Capital'[2] in the professional classes. It would potentially need re-imagining to set the dilemma in a different context with references that other target audiences could identify with.

4.2 Outcomes for public and invited guests

- We received 56 responses to a post-event evaluation form, representing a response rate of 24%.
- We asked audiences to rate their prior knowledge of Synthetic Biology in advance of the performance on a scale of 1-10 with 1 being no prior knowledge and 10 being an expert. The majority (43%) rated themselves between 1-2 in terms of prior knowledge:

[2] http://www.kcl.ac.uk/sspp/departments/education/research/Research-Centres/cppr/Research/currentpro/Enterprising-Science/01Science-Capital.aspx

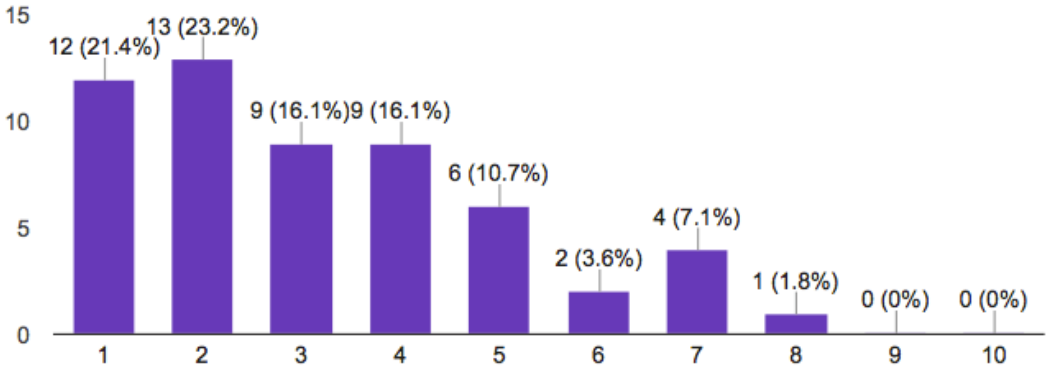

Table 3: Prior knowledge of Synthetic Biology (1=no knowledge/10=expert)

- We asked respondents to rate how much they learnt about Synthetic Biology and its applications:
    - 37.5% said that they learnt lots
    - 60.7% said they learnt something
    - 1.8 % (1 person) said they learnt nothing or hardly anything. This person also said they had no prior knowledge of Synthetic Biology.
- In the comments section of the evaluation survey a significant proportion of people responded to say they had been motivated to find out more:

  "(I will) look into Synthetic Biology and to investigate my own views around it".

  "It made me want to learn more about Synthetic Biology and its uses".

- We asked people to provide three words that described their experiences of *Invincible*. The most significant word by a long way was "though-provoking" with 24 counts. See table 4 below:

Word	**Word count**
Thought-provoking	24
Moving	6
Intimate	6
Interesting	6
Innovative	5
Challenging	5

Table 4: One word-reflections

- A total of 46 individual words were put forward to describe the performance (see image 1 below):

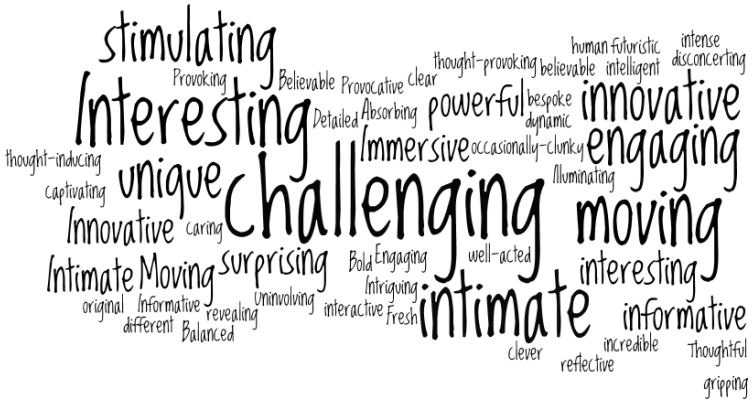

Image 1: word cloud adjusted without "thought-provoking"

- On the whole the feedback was overwhelming positive in tone, one person did say it was '*occasionally clunky*' and another that it was '*uninvolving'*. On interrogation, the later commentator enjoyed the performance, but would have liked more discussion about the making of the drama in the Q&A, this observation was reflected in a number of comments.
- There are no clues as to what the audience member found '*clunky'* in their comments, however another audience member used the same word to describe the voting process used throughout the performances:

  "I would suggest possibly not using the smiley faces, it was quite an easy way of recording people's views but it felt clunky and intrusive. Being able to vote anonymously would be nice - maybe electronically. The questions also disrupted the narrative and stopped it really feeling like a play or a piece of theatre".

- The use of the smiley-faces provoked mixed responses, which indicates that there may be room to develop this area of the performance further (as also suggested in the schools' feedback). For example, one respondent said that they "*hated using the sad-smiley face cards!",* another reflected that it wasn't the best use of the Q&A time:

  "*I thought that looking at the pictures of smiley face sad faces wasn't the best use of time, but the discussion did force you to register your thoughts amongst the performance."*

- In contrast one audience member, who would feel less inclined to engage with public discussion, felt that they gave the Q&A a good focus:

  "I often feel too shy to in similar situations as I don't really like that kind of "off the cuff" public speaking. The projection of photos and encouragement to comment on/ defend our votes was a really good technique for this."

Another person commented positively on the role of the 'smiley cards' as a theatrical device:

"I liked the contrast of intimacy, with the actors so close; and detachment, with the voiceover questions from the child, and the smiley face/frowning face cards to respond".

4.3 A collection of key themes emerging from the evaluation

Creating an ethical stance

- A distinctive feature of *Invincible* was that it was neither pro Synthetic Biology or against it. This was a significant factor in the authenticity of the performance and the relationship it built with audiences. It allowed the participants to project their own values, emotions and judgements onto the fictional world, and let this story influence their thoughts, feelings and prior conceptions. The risk here was that audiences may leave the play feeling more concerned about Synthetic Biology and its uses than before. In some cases, this did occur, in others it didn't.
- This ambiguity helped to enable discussion and equip audiences to develop their own ethical stance on Synthetic Biology:

  "It was interesting that the actual example had so much ambivalence in it which forced you to think carefully".

  "Incredibly thought provoking and challenging: no easy answers but lots to think and talk about".

  "Although I'm aware of the applications of SynBio I hadn't thought at length about the wider political and policy implications that need to be considered before rushing into it".

- There was evidence that the performance challenged people to think about and reflect on their own stance:

  "Interesting revelations about me, i.e. am I a sit on the fence, am I a traditionalist after all even though I didn't think I was one?"

  "Pause and consider different angles and wider implications before jumping to first conclusion. This should be applied to so many aspects of life, if not all!"

- Several responses from audiences indicated that the play connected them more deeply with what it is to be human and what is our relationship with nature. Whilst this is related to developing an ethical stance, for some audiences it clearly introduced new ideas, and generated to new insights regarding our relationship with our natural environment:

  "Issues involving notions of what it is to be a 'natural' human being are even more complicated than I thought".

  "I thought you raised questions about what it means to be human very well and the way that technology (not just SynBio but obviously this performance focused on that) might influence our understanding of this".

- In a few cases audiences conflated their view on Synthetic Biology with the fictional application presented in *Invincible*. This may be worth noting for future performances, in particular considering other steps to help audiences separate out the two following the show.

  "It's better to have a complete experience of one's emotions (positive or negative) than to live a life that's sanitised. (I learnt that…) the risks of Synthetic Biology outweigh the benefits".

- The development of an ethical stance was not restricted to audiences, but also to the creative team and researchers taking part in the project. Members of the creative team described "discovering" their own position, alongside "a robust interrogation of that position through both conversation and artistic development" of which one part were the encounters with scientists. Several of the researchers commented that they had learnt more about their research and its applications might be perceived by members of the public:

  "I has allowed me to carefully think about what aspects of Synthetic Biology are important to me and the worries that I have. These were not always easy to precisely define and this process has allowed me to think about this is a new way -- often from the view point of others outside the scientific community".

<u>Off target consequences and the value of responsible research</u>

- A number of comments suggested that attendees were glad to be involved in discussion on Synthetic Biology, and that they felt reassured that these conversations were happening:

  "I'm glad that researchers are sufficiently aware that what they are working towards could have serious ethical issues and societal consequences, so they are up for asking for public input on it".

  "This is an important issue that needs to be thought of by the public as well as scientists and intellectuals".

  "Engaging the public with the potential uses of research is vital, but complicated. How scientific advances should be used is not a black and white issue".

- During the performances concerns surfaced about the pace of scientific change and the challenge of predicting the consequences of innovation. The data appears to indicate that these concerns existed prior to attending, but *Invincible* did little to allay them:

  "It generated some really big questions about the applicability of the tech across a range of illnesses and reflection on where to draw the line of what can be done/should be done with the tech".

  "As someone who believes strongly that science should be restrained by ethics, I was concerned by the potential for abuse that will accompany SynBio".

  "(I took away) That scientists are often very bad at predicting the consequences and ramifications of their innovations and therefore developments such as Synbio, while potentially very beneficial, need to be very carefully considered before implementation".

- Many respondents did not have the answer for what was required of scientists, and in many cases there appeared to be an element of acceptance that scientific advancements will lead to unintended consequences.

  "That scientific interventions cannot take account of the social circumstances in which they are used, or which will arise later".

  "Human beings are able to progress at an impressive speed and provide solutions to great diseases or other issues, but it feels like most of the time they are progressing in the dark, never really able to anticipate the consequences of their actions. We need to progress in wisdom as fast as we progress in science".

- The responses from scientists were mixed in terms of how the interactions with audiences and their feedback about their Synthetic Biology might influence their research. Whilst 90% (n=11) of the researchers who completed the survey felt the project had influenced their research, the open text responses indicated this happened in different ways with different levels of impact. Some researchers felt it had very little or no influence:

  "My research is very blue skies and there aren't any obvious applications of it such as the treatment in the play. I feel that my research is so far removed from the issues that were discussed in the play that the impact that the play had on my perspective didn't affect how I feel or think about my research".

  Some felt it had moderate influence:

  "I don't think that the project has necessarily changed how I think about my research as a whole, but it's definitely informed it - framing it in the context of public perceptions of what are and aren't ethically acceptable applications of synbio".

  In a couple of cases researchers provided some precise examples of how it has changed their thinking, or raised their awareness a little:

  "I has allowed me to carefully think about what aspects of Synthetic Biology are important to me and the worries that I have. These were not always easy to precisely define and this process has allowed me to think about this is a new way -- often from the view point of others outside the scientific community".

  "One clear thing that came out of the Q&A sessions that I was involved in was a strong sense that using nanoparticle-based therapeutics for physical vs mental health conditions had very different ethical implications for the public (with the majority believing that self-regulating systems should only be used to treat physical conditions)".

<u>The quality of theatre</u>

- Several people commented overall on the nature of the theatre piece, the quality of the acting and the script:

  "It was a really excellent show - interesting, thought-provoking and enjoyable to watch. I loved the intimacy of the space and the interplay of the recording and questions with the live scenes"

  "I found the site-specific and participative theatre fresh and exciting".

  "A great, unique theatre experience".

- Others picked up the themes of human emotion and even mental health being a 'natural' or 'unnatural' construct:

  "A comment to both that this case study of mental health was extremely well chosen - particularly the issues it throws up around uncertainty about inherited vs environmental factors, and the questions of living an "authentic" human experience, all of which were excellently and sensitively handled in the piece."

- Researchers also reflected on the quality of the theatre:

"The believable, relatable portrayal of a normal family, and the immersive nature of the staging really drew you in. Even at the fourth performance I was noticing a new detail in the dialogue, or in the props decorating in the flat, and each time being prompted to think in a slightly different way".

- There was also a clear indication from researchers that the performances were based on robust science.

  "If I'm honest I was expecting the science to get butchered a bit, but I was very pleasantly surprised by how well grounded it was in actual research".

  "I think the ideas are definitely robust, given the recent developments in the field. The "nano-cages" were also a nice reference to the actual research going on in Bristol"

- Likewise, the ethical questions that exist around the science were seen to be well represented by researchers:

  "From a social science perspective, I certainly saw some key social scientific themes and concepts coming into the performance".

  "The most important things are the questions raised around the play: all of them were real, ethical questions debated within the SynBio community".

- One member of the creative team flagged a concern that some of the science was not as clear as it could have been.

  "I was struck by how often 'I still don't understand what Synthetic Biology is' came up (in Q&As)".

  It was suggested that a clearer explanation could be worked back into the drama.

- A significant proportion of audiences would have liked to have asked the production team, cast or scientist questions related to the process of creating performance. This may be reflective of the invited audience group (i.e. theatre makers, researchers and public engagement practitioners) or may be a general trend within the public audiences:

  "What was it like for the actors having the audience up so close to them, in such an intimate environment?"

  "How did you manage to assimilate all the scientific information to develop a gripping and accessible family drama?"

  "I would be really interested to know why this particular application of Synthetic Biology was chosen as the basis for the performance".

<u>Engaging with the Q&A</u>

- For the school audiences teachers felt that it helped the students to make sense of the play and to engage with a scientist:

  "The Q&A at the end was great and I feel really important. Without it we would have left with a lot of questions, but hearing from the experts and having a chance to reflect helped our understanding, gave the students a chance to discuss and think more deeply about what we had seen"

- At times the transition from the performance to the Q&A may have felt awkward. A member of the creative team summed this up well in their feedback:

  "Public audiences were perhaps at first a little surprised by the format of having a discussion immediately after the play, but nevertheless they generally entered into them with generosity & curiosity. I do think that (there was a) tricky shift of going from a piece of theatre about an imagined application of something many people had never heard of before, to the discussion that felt more educational & expert. From an audience member's point of view, they're suddenly being asked to do something very different."

- On the whole however, public audiences and invited guests described the Q&A as being really important and a great opportunity to engage with cast, crew and scientists. Some felt it helped them to engage with the science better, and to ask the questions they need too. Several people felt it was well chaired and commented positively on the inclusivity of the Q&A and how good it was to hear from other audience members.

  "I thought it was wonderful. The audience (me included) felt comfortable asking questions and the answers were honest and open prompting discussion and further questions. It was a very inclusive Q&A when often these can exclude people that don't feel they are 'experts'. It managed to be entirely about the content of the play without any of the 'loviness' often associated with after play Q&As"

  "I was shocked at some of the hostile and negative opinions of the rest of the audience. It made me realise how much I live in a bubble, and can easily forget that people with quite anti-science views exist"

  "It was really useful, well-chaired, interesting and a vital part of the whole performance"

- A few people were less positive about their experiences:

  "I did not find that the Q & A added anything to my understanding nor did it help me reflect on the play"

  "I thought that looking at the pictures of smiley face sad faces wasn't the best use of time, but the discussion did force you to register your thoughts amongst the performance"

  "It was not useful, it really weakened the whole experience"

- The evidence from researchers suggested that the Q&A was a really valuable part of the learning experience:

  "I really enjoyed being the scientist and doing the Q&A. It was really interesting to see the public react to the questions raised by the play (happy/sad faces) and discuss it afterwards".

  "Every audience was so different that you couldn't really predict which direction the Q&A was going to go in before it began, so it forced you to be responsive and think on your feet. It was a welcome to change to have such open-ended conversations, rather than just answering simpler fact-based questions".

  "It has helped me to better explain my research to a non-scientific audience".

- One clear steer coming from audiences was that the Q&A felt rushed or that it could have been longer.

Being part of the process

- A strong theme in the evaluation was how the collaborative process enabled learning. The creative team learned about and developed their views on Synthetic Biology, ethics, power relations, research funding, undertaking extensive research and conversations with friends, family, peers and the researchers to inform their views and develop the characters in *Invincible*.

  "I knew nothing about Synthetic Biology when I started the project. Through the last two years the key changes have been a wealth of information from which to discover my own position, and a robust interrogation of that position through both conversation and artistic development, within which sat the face-to-face encounters with scientists actively pushing forward innovations for the future."

  "Getting to know real-life scientists has made me reflect more on the fact that everyone is basically working towards a perceived 'good'. There isn't really such a clear-cut category in SynBio (or anything) but it's worth always remembering the good ambition & thereby working collaboratively - sharing a responsibility."

  "I remain worried about rogue applications in spite of being repeatedly reassured this can't happen. I can see it would be hard for a single mad scientist but there are plenty of mad oligarchs!"

- A further theme that emerged from the creative team was how working with the scientists improved the authenticity of the piece:

  "Their research fed directly into the writing of the play, the ethics and debates embedded (hopefully) in the script and the characterisation within and focus of the story. I would have written a different (less balanced and more aesthetically heightened) play without the scientist's interventions - this became a new exercise in balance for me as a playwright."

- Feedback suggested that the researchers had found the whole experience, particularly that of developing the performance in partnership with Kilter, a positive one.

  "I really like the fact that our concerns about the way scientists were depicted were taken in account in the next version of the play. It was truly a cooperative work".

- The data suggested that researchers found the process interesting and valued the independence of Kilter in making sense of the science, whilst still being a realistic and scientifically robust performance. Kilter's expertise was crucial in guiding the process, this was particularly important to researchers as they had no prior experience on working on this nature of project and therefore could not visualise the end product.

  "Kilter have so much energy and enthusiasm for what they do, which really enhanced the experience for me. Their belief in the process was very motivational, particularly in the early stages when I lacked any vision of what the end performance was going to be like!"

- Likewise, it was evident to researchers that they had played an influential role in ensuring the performances were authentic. At several points feedback was offered on the script which was clearly taken on board by the creative team. The evaluation suggests that the way in which this was handled was crucial for the scientists' long-term endorsement and support for the project:

"The first drafts of the play were less scientifically robust, but after a few meetings and our inputs, everything was really improved".

"In the first proposal for the play, the narrative hinged on the SynBio treatment being un-trialled and surreptitiously injected into a child alongside a routine vaccination. From a creative perspective this sounded great but it was an image that, as ethically-conscious scientists, we were completely against portraying. When they were willing to go away and re-write such an integral part of their initial concept I was confident that they were committed to producing something that we were all fully supportive of, and actually the result far exceeded my expectations".

- Whilst there was a lot of Synthetic Biologists involved in the project, it was noted that there could have been more involvement from social scientists. This would have helped share responsibilities and pressures.

- In many cases researchers reported learning new skills and ways to engage the public with research. Particularly of note was the unique experience of working with the arts and how it lends itself to more surprising and emergent discussions:

"Before this process I would have never thought of working with actors and actresses to put on something like this. Having seen the impact it can have on the public, I'm definitely more receptive to new ways of working!"

What will you do as a result of *Invincible*?

We asked public audiences and guests what they might do in response to the performance. By far the most common response was to learn more about Synthetic Biology. However, other key themes emerging were:

- Engage with future debates
- Challenge my own ideas and pre-conceptions
- Discuss with friends
- Look out for more of this type of production

Quotations from the responses include:

"I have already talked to friends/colleagues/family about the production and what I learnt about Synthetic Biology and how I feel about it".

"As a greenie I'm already on red-alert about scientific interventions, so this field of research is a new thing to worry about! But I am also having to face my own inconsistencies and hypocrisies, so I'm now going to learn more to better inform my prejudices. Also, apart from ethical issues, the site-specific theatre has enriched my ideas about performances".

"I shall be on red-alert for news about scientific developments, but mainly, I will be examining my own prejudices and hypocrisies, particularly about medical interventions".

"I am going to be more aware of Synthetic Biology but also check the UoB department for updates - it is interesting to have a university in the city at the leading edge of this stuff!"