# Terahertz, Topology and Telecoil Loops: Going Beyond Standards (*Transcript*)

## Dr Jessica Louise Boland

## University of Oxford Disability Lecture 2023

### Sarah Stephenson-Hunter

Good evening. Thank you for bearing with us. Good evening to those of you in the room and good evening to those of you online. I say good evening, and sometimes for these events, we have international guests, and so in case it's not evening where you are, good whatever! My name is Sarah Stephenson-Hunter. I am the current Joint Interim Head of the Equality and Diversity Unit here at the University of Oxford, and also the Staff Disability Advisor. **It is my pleasure to just briefly welcome you here to the event, to tell you a little about the housekeeping**, and then I will hand over to our Chief Diversity Officer, Tim Soutphommasane, who will introduce the speaker and we'll crack on with the event. It is a pleasure to have you all here. We have a full agenda, packed agenda, lots of learning and discovery as we go, so that's great.

In terms of housekeeping, for those of you actually here in the building, we have bathrooms, which do include a wheelchair accessible bathroom, and which are behind you. We do apologise that there is no gender-neutral option.

There are no fire alarms scheduled, which is good to know at this time of night. So hopefully they won't go off, but if they do, then you should follow the events team here. They will lead us out to the appropriate place.

For those who are joining on Zoom, and thank you for bearing with us on Zoom while we sort out technicalities, as you will hear throughout the evening, we're very pleased that we have been able to offer BSL online this evening. That has added a level of complexity, but we have got there with that. We also have captioning and for those of you on Zoom who aren't familiar, if you press the CC button for closed captioning, then you should be able to enable that. We actually have professional captioning, not AI generated captioning, which is good, but which has its limitations.

In terms of the BSL interpreters, you can re-size or hide the interpreter as you wish within Zoom, so please do whatever helps you feel more able to participate with that.  If you have any problems with Zoom, then please do ask the co-host.  We have a team of people back monitoring the Zoom, so any technical issues there please do ask for assistance.  I think that's everything.  Without any further ado, I shall stop there and I shall hand over to our Chief Diversity Officer, who is going to introduce the speaker.

## Tim Soutphommasane

Thank you so much, Sarah, and welcome, everyone who is here in person and joining us online.  **What a pleasure it is to be introducing this year's Disability Lecture here at Oxford!**  It is the University's ninth annual Disability Lecture, and I'm very pleased to say, as we know, it is the first one to be British Sign Language interpreted.  I've been polishing up on my British Sign Language, so I think this [BSL for 'Congratulations!']  and this [BSL for applause] is definitely called for.  Hopefully I have got the same – I'm more familiar with Auslan as opposed to BSL.  But this event is a great testament to the community of academic and professional colleagues who are working to ensure that Oxford is a place and has a culture that is inclusive of everyone. And I want to acknowledge in particular the work of the Equality and Diversity Unit, and the Disability Advisory Group, who have put together the event for this evening; to Catherine Walter – I don't know where she's gone, she appears to have left the room momentarily – but to Catherine and colleagues from the Disability Advisory Group, I want to say thank you for your leadership in disability and inclusion, and indeed on equality, diversity and inclusion more broadly.  In the short months that I've been here at Oxford, Catherine has been a valued voice of counsel, and someone who I know will always speak up for what is right, and she's a wonderful advocate and a role model.  And the same is true as well of Sarah Stephenson-Hunter, the University's Staff Disability Advisor, and for the past few months Joint Interim Head of EDU.  A big thank you for everything that you do, Sarah.

Now we often hear people ask why diversity matters for universities.  I think the answer's very simple.  **Diversity is at the heart of academic excellence.** It enriches our teaching, our learning, and our research.  And where we are able to remove barriers and biases, that doesn't hinder our academic mission; it enables it.  It enhances it.  For example, in the years since women have engaged in medical research, advances in knowledge about women's medical issues have accelerated. Moreover, the ways in which diversity improves research and the advancement of knowledge are not always predictable. For instance, studies of American Sign Language by teams that have included deaf scientists have led to exciting new findings in fields such as neurolinguistics.

Now for those of us who work on matters of diversity and equality or equity and inclusion, this is a straightforward proposition.  But not everyone, of course, sees things this way.  And it's the responsibility of those of us who are committed to EDI to make sure that we take the opportunity to start and continue conversations, to shift attitudes and understandings, indeed, to keep working for change.

Well, events such as tonight are one way that we can help build understanding of diversity, as well as celebrate those who have made important contributions, and tonight we are so pleased to welcome Dr Jessica Boland to share with us her work in quantum materials – and I confess, Jessica, I know nothing about quantum materials, so I'm going to learn a lot tonight – as well as her experiences as an academic with severe hearing loss.

**In the UK today an estimated one in fifty people have hearing loss that is severe enough that they cannot hear the most conventional speech.** By 2035 the number of UK adults with substantial hearing loss is expected to reach 14 million.  14 million!  Now those are significant numbers.  But how well does the academy or higher education provide, then, for students and academics with hearing loss? This is a question that I believe Dr Boland will be exploring among other things in her lecture tonight.

**A little bit about Dr Jessica Boland.** She has conducted ground-breaking research in new topological quantum materials for technology.  She is an alumna of Oxford, having completed her DPhil here in 2017, and that DPhil involved developing a new technique for extracting key opto-electronic properties in nanowires. Is that right? OK. Great! I've been doing my research here!

She was awarded an EPSRC Doctoral Prize to continue this work in solar cell applications, and as we can see on the slide there, she is now a Senior Lecturer of Functional Materials at the University of Manchester and a UKRI Future Leader Fellow.  Dr Boland is also an active member of Tigers in STEMM. This is a group of UK professionals and students in science, technology, engineering, maths and medicine who are passionate about improving equality, diversity, inclusion and accessibility.  So, to Catherine and colleagues, a really inspired choice to invite Jessica to give this year's lecture.  We're delighted to have you back in Oxford.  Will you please join me in welcoming Dr Jessica Boland.

## Dr Jessica Boland

Thank you for that wonderful introduction.  It's really, really heart-warming to hear that, so thank you.  And it's great to be back in Oxford as well.  I'd also like to thank Sarah and Catherine for the invitation.  It's a real honour to be here.  Especially because my predecessor at Manchester, who runs the

Disabled Staff Network, Hamied Haroon – I think he's online – also gave this two years ago, and he's been an inspiration for me, so it's really an honour to kind of follow in his footsteps, and all the other people that have given this lecture.

I promise I'm not going to scare you too much with topology in this talk. And I really loved my English teacher telling me, if you use alliteration and the power of three you'll have a great title, hence Terahertz, Topology and Telecoil Loops.

**I'm going to start by just giving you kind of an introduction, a little bit, to my career,** which has already been explored a little bit. But what you probably don't know is that I wasn't always interested in physics and engineering.

So at the top of this slide there's an actual cute photo of me in a little red tutu back when I was about 12. So I wanted to be a professional ballerina before I thought science was a good career. I didn't realise that you probably should hear the music to be a ballerina. But actually, blissfully, I think the fact that I didn't grow more than five foot was more of the issue that I couldn't be a professional ballerina. And my parents told me, you're doing well at school, keep going and just see what other options are available. So I did have an explore. I thought *The Mummy* was a fantastic film, and so maybe I could look at some skeletons and become an archaeologist. I might still do that if science doesn't work out for me.

There's a picture here of a Roman soldier. I didn't want to be a Roman soldier, but I considered doing classics as well, maybe some Roman history. Then I tried to explore languages. Eventually I found my way to maths and physics. And the real reason that I thought physics was for me was because a maths teacher said 'Please stop asking me why maths is important and go do a physics degree, and you won't get bored'. And she was perfectly right, so thank you to Mrs. Wright, my maths teacher, for where I've got today.

But everyone should consider how science and engineering affects your lives. And you might have an unconventional start into it. So you know, if you're sat there in humanities, science might be for you – I'll try and persuade you. But that's how my career really started, as I liked physics a lot. **And here's a timeline of just kind of how I got to becoming a lecturer at Manchester.** So my Master's in Physics was completed at Exeter and I got to do a research project for the first time. And that was with Professor Sir John Roy Sambles, who recently led the Institute of Physics, and I got to look at meta–materials, which they told me could make invisibility cloaks.

Who doesn't want to make an invisibility cloak? I certainly did. I didn't make an invisibility cloak, sorry, during that Master's project, but I did realise that doing applied physics and experiments was quite exciting, and I thought, let me explore that a little bit more.

**I had a year in industry**, in Hewlett Packard Labs, and that was trying to make a colour Kindle. So the Kindle liquid crystal display is reflective, trying to make that.  And I thought, 'Ooh, Engineering is pretty cool as well, so maybe I can combine physics and engineering'.  At the end of my undergraduate, I wasn't sure if I wanted to go into industry or whether to stay in academia.

And I explored around and **I found Professor Michael Johnston's group here in Oxford**, based just at the Clarendon Laboratory on Parks Road. And he was looking at terahertz spectroscopy and how that could be used to look at new materials. When I went to see his lab, I saw there was lots of lasers in it.  I thought I'd become a Bond villain and that was really the logic behind that PhD project.  But I had an absolutely fantastic time.  I didn't become a Bond villain and I did get to use lasers, but I got to find out about these kind of exciting quantum materials.  And Michael was a fantastic mentor and supported me all that time during my PhD and really helped me to succeed.  It was a massive jump from undergrad to PhD. And that's something I'll talk about later in terms of your support tends to drop off as you go through.  So his support in making sure that I could access the lab was really quite vital, so making sure I didn't quit that PhD.

At then at the end of the PhD I didn't know if I wanted to be in industry again, or academia, but realised that I really enjoyed teaching. And I didn't want to join a school, but I did think maybe academia could be a good combination of research and experiments and teaching.  So then **I pursued an academic career** and that involved moving to Germany, moving to Bavaria to do a post-doc and then finally landing myself at the University of Manchester, which has grey weather all the time and rains.

So during this time as well, **this is now a timeline that I'm showing about my relationship with my disability**. Now I'm calling it a hidden disability, because when I was younger I was trying to hide it.  It was something that I was embarrassed of.  I'm not embarrassed of it at all and you shouldn't be embarrassed about it.  But when I was younger, it was something that I was finding quite challenging to deal with.

**So I've been deaf with a little 'd' since birth.**  I grew up with a hearing family.  My parents are hearing.  All my brothers and sisters are hearing. So I grew up in a hearing environment.  So when we see a little 'd' with deaf, that means that English is my first language, brought up in a hearing environment. If you see a big 'D', this usually means that sign language, BSL, is your first language and you're part of a Deaf community and you've been brought up in that community.

So when I was younger, I was very much a small ‘d’ in a hearing world, trying to access the support that I needed. **I didn't get diagnosed and get hearing aids till quite late** and you'll see kind of why later on that diagnosis was quite late. So it was secondary school when I first got hearing aids and radio aids. I have a love-hate relationship with my hearing aids. Probably because I got bullied at school for it. I now am pretty proud to wear them, but I still have that love-hate relationship with them.

**University: used hearing aids all the time and had quite a few operations.** My dad likes to call me the Bionic Woman, because I now have artificial ears. So after those operations I have artificial eardrums and a metal implant inside my ear. And then when I started my job, I then had to assess: How am I going to deal with my hearing loss? Maybe I need to start thinking about something else. So I'm currently in the process of looking for a bone-anchored hearing aid, because it's too sore to wear these hearing aids now for a long time, so I'm looking towards a bone-anchored hearing aid for my hearing loss, and I've started to learn BSL.

**So when I moved to Manchester, that's when I really started to learn BSL**, and have absolutely enjoyed it. It is a beautiful language and it has also helped me so much now in my science career. And learning science signs has really helped as well with the concept of teaching, which I'm going to talk about a little bit later on.

Something I did notice though as I'm dealing with my disability while alongside this research career is **how technology has changed**. So on this next slide I've just got some images of how technology has changed from 1973 to today. So in 1973 there's this lovely picture of a mobile phone that is the size of your head. You have to carry a battery pack and it's really heavy and can only make a phone call. Hands up please in the room if you remember these mobile phones. Yes. Thank you for being honest and brave.

Now as we move along from 1973 to today, all these photos you're seeing that the phones are getting smaller and smaller. Your smartphones are now really really really quite thin and they're practically computers in your hands. So technology has changed quite significantly. Not just with my hearing aids, but also with all of the devices that we currently own. And I found this particularly fascinating. And this is kind of why I started to think about these quantum materials and research.

**So I was trying to look at next generation devices**, from starting at undergraduate at Exeter with my invisibility cloaks. I've got a picture of Harry Potter here in his invisibility cloak. I didn't achieve that, that's not what we managed to do. But we were trying to do cloaking in the microwave frequency range. So radars of planes, trying to cloak that.

**And something that I'm doing now is in the terahertz range**. So this coloured image in the middle here, you've got a hand that's lighting up red. It's lighting up red because your hand is really really hot. The types of devices that I'm making are trying to cloak that. This square blue patch on top of the hand is blue because that's cold, it's shielding the heat behind the hand. So you can't see the heat any more in the hand. This is effectively a cloaking device. So, it's invisibility cloaks, but not in the 'visible', sorry. That's very difficult to do. Not impossible, but difficult. So that was exciting – can I do that in the microwave and terahertz range? But also thinking about the displays as well, how can I make displays faster? I really enjoyed kind of physically making those devices.

**So my whole research aims have been based around smaller, faster and smarter.** That's what technology is doing. It's going smaller, faster and smarter. We're pretty small already. A transistor in your smart phone is currently the size of five nanometres. That's very tiny. That is like a million times smaller than a piece of hair. So very tiny, but we're still trying to get smaller than that.

We also want to get faster. And when we talk about faster in a device, we're talking about current flow. Can we get a current in your device moving from one place to the other as quick as we can? And smarter, we're talking about can we carry extra information when we're using a device.

So let me just show you how I'm doing that. So smaller – here I've got a diagram showing a scale. So, couple of examples. Tennis ball, size of your hand, you can say is about 10 centimetres. A drawing pin, the tip of the drawing pin is 1 millimetre. If you divide that roughly by a thousand, you're getting in between the size of a single hair and a red blood cell. Divide it again by a thousand and then you're getting on to the size of an order of bacteria and viruses and DNA. So really, really tiny. DNA is ten nanometres. So your transistors are smaller than DNA. Terrifying, right?

And to kind of help you imagine how small this is, **going from 1 metre to 1 nanometre is exactly the same as going from the diameter of the sun to my height or the height of a baby giraffe.** So it's quite a difference in scale, and it's really difficult to start seeing these **types of nanomaterials**. But these nanomaterials do exist, and this is the type of quantum materials that I'm looking at. Here is just a couple of examples. So we've got things called nanowires, molecules, graphene (if you're from Manchester you have to say graphene, I promise we don't get paid every time we do), but graphene, which is an atomic layer. If you roll that atomic layer into a cylinder, you've got carbon nanotubes. And you could put them in spheres and get molecules as well. So these are the types of nanomaterials that people are looking at. And all of these have quantum behaviour.

That's how we're going smaller. **How do we go faster?** I have a picture here of a lorry. A massive lorry. And this I'm using as an example for the material that we call silicon. All of your devices are made out of silicon. So your smartphone currently uses silicon transistors. Most technology is based on silicon. But it's like a lorry. So you have this big lorry. Usually those lorries if you're sat behind them on a motorway have a speed limit, so does silicon. So silicon's speed limit, we call it mobility, and it's called 1,400 centimetres squared per volt per second. Don't worry about that, just keep the number 1,400 in your head. OK, that's currently what silicon can do.

Next to it I've got a picture of a Ferrari, because that's what I'm trying to find. I'm trying to find a material that's a sports car. A really really fast material that beats this electron mobility, this speed of silicon. So that's how we're going to try and get faster. We're going to measure this concept that we call electron mobility and we're going to see if some materials can go faster than that.

**For smarter, this is about carrying information**. So on the top here I'm using an on/off signal. So you've got a line that's high and then it goes down low for zero, up again for one, zero, on/off signals. When we're trying to perform operations with a smartphone or in a quantum computer, we're using this on/off signal. At the moment your smartphones do it just with voltage and current. So your battery is giving a voltage and a current, and it's giving you an on/off.

**There are some really cool materials, the quantum materials, that have extra things that we can play with.** So if we imagine that we've got a current going in one direction, that current can have something called spin that can go anticlockwise and clockwise. It does link back to ballet, because if you think of a ballerina pirouetting, they can go in a straight line, but they can turn either clockwise or anticlockwise. Our current, our electrons, can do that as well, if you like.

That's one way of thinking about it. They can have spin up, spin down, which is spinning anticlockwise and clockwise. If we can read 'Is an electron there?', that's an on/off. If we can then read the spin, up-down, that's another on/off, so that's two channels. So that's a way of getting more information and getting smarter.

Another cool thing we can do is instead of using electrons at all and using current, we can use light. Light is the fastest thing you're going to find in the universe. It's got the fastest speed that we can have. So also if we can use light instead of electrons, that's another way of getting faster and smarter.

And this is where **the topology part comes in, so topological insulators**. You're all going to be experts in a second, it's going to be great. [laughs] These materials are very very strange. I've got an image here where I've got a cube that's blue.  And that cube is insulating. So if I take a material, the inside of the material doesn't have any current flow, it is insulating. But on top of that cube I've got some red surface. It's a different colour because the surface is actually a really really good conductor.  So you've got a material that inside doesn't have any current flow, but the surface has really really fast currents.  So the surface is my Ferrari.  It's my new candidate for that faster material.

I told you to remember the number 1,400. Woof woof woof! **Some of the speeds in this material at the surface can go up to 10 million centimetres squared per volt per second.** So 1,400 to 10 million, that's potentially extremely fast.  I'm sorry, at the moment what we're say in devices, it's always 20 years away, so don't get too excited, OK?  So there is a challenge of isolating that bulk in the surface and that's currently what our research is trying to do.

But as well, on this kind of new solid, what we've got to add to this picture now is that we now have two currents.  We've got two lines over that cube, so we've got one that's going clockwise around my cube, and one that's going anticlockwise.  **So those materials are not only faster, but they have two channels now, so more information.**  And what's even spookier about these materials is that they don't care if there's defects. So if you put a horrible atom in the way that doesn't want to be there, the current can just ignore it, it doesn't get back-scattered, it will just keep on going through. So a way to think about these materials is like you skating on an ice rink.  So you're going round in a circle, there's less heat and less resistance.  So these materials could be more energy efficient.

**Finally, terahertz radiation**.  So we've got these really cool candidates. How do we then look at these materials? And that's where terahertz radiation comes in.  **Terahertz radiation is in between microwave and infrared radiation**.  So I've got a scale here of the electromagnetic spectrum that goes from radio, microwave, infrared, visible, UV, X-ray and gamma.  Terahertz sits just between that microwave and infrared radiation.  Infrared radiation is heat radiation and microwaves is what you use to cook your dinner. So terahertz is just in this beautiful sweet spot.

And I've got two pictures here to show you kind of how we use the terahertz radiation.  It's very similar to a thermal camera.  If you were to use a thermal camera, you see if something is hot or cold.  So the image on the left is a picture of a wolf or a fox – not quite sure, but most of the wolf and fox is in a colour of purple, which is indicating it's warm but not too warm.  Its eyes and its mouth and its ears are in bright yellow, so it's really high intensity, 'cause that's the hottest parts on that particular image. The one on the right is an image of a hand.  The hand is really really hot so that's coming up in red.  Lots of intensity in this image, that's lots of infrared radiation.  On the hand is a caterpillar.  That caterpillar is in blue.  It's much much colder, so you've got this beautiful red hand and then a tiny blue caterpillar because the caterpillar is colder.  So **infrared cameras can show us if something is hot or cold. If we do this with terahertz radiation, it's similar, but this time it's showing us if your material's conductive or not.**

So it's showing you the speed of your material.  So this is what we're effectively doing when we use our lasers and our terahertz radiation.  We're taking images of these really tiny nanomaterials.  We're combining the terahertz radiation with a microscope.

This is a picture of my lab.  I'm going to describe it. It's effectively a mess with lots of optics on it.  Lots of optics, you can't really work out what's going on. There's lots of mirrors, there's some lasers on the table, but it is a little bit complicated.  Also, I am the size of the width of this picture. So it's quite big kit as well that we have to use to use this terahertz radiation. But what we can get out of it is these lovely **3D maps of these nanomaterials that can show us if it's conductive or not**.

So on this slide I've got a grey image where I'm seeing a nanowire.  This is a topical insulator nanowire.  It looks like a piece of candy cane.  So it's a cylindrical shape, and it's got lines across it.  The actual shape of your nanowire is just a cylinder, and if I look at the grey image it just looks like a grey cylinder.  There's no kind of special features.  If I then take a terahertz image of this, you have some really bright lines of intensity, so it starts to look like that candy cane. So the red parts of your candy cane, the kind of lines, you've got some really bright intensity lines. And those are regions that are more conductive.

So just to remind you that this single nanowire is a million times smaller than a width of hair.  It's quite hard to look at these things, but we can show you how conductive it is.  And we can map that in 3D, and we can also look at the surface and the bulk independently.  And that's kind of what I'm up to at Manchester.  So the microscope that takes this is actually unique now in the UK.  It can go down to low temperatures, to minus 270 degrees Celsius, pretty cold. It can map the conductivity on these types of nanometre length scales, and it can also do it on very quick timescales, so on the order of kind of 50 femtoseconds, that's ten to the minus 15 seconds, very very quick.

So that's kind of what we're up to. But all of my research has been focused so far on answering that smaller, faster and smarter.  And I think we've got a good candidate to keep exploring.  So we've got something that can be only two nanometres thick, that's smaller than your transistors (Woohoo!), something that can be a hundred thousand times faster than silicon. The speed at the moment in terms of a device isn't as good as we can get, but that's half of what we're looking at, and we can go multifunctional.

So that's really good. **All of my research so far has been smaller, faster, smarter. But that's also what's been happening alongside that in terms of the devices that I use to give myself access as well.** So all of the hearing aids, all of the technology for that has also been getting smaller, faster and smarter. So since I started kind of my journey with hearing aids, and they're now bluetooth enabled, for example. So I think that actually science and accessibility are a really really good link together, and we should use the science that we're doing to give people access as well.

So that's how they link for me as well. I'm going to switch the talk a little bit now to focus on that side of it, and **accessibility in STEMM**, and how we can - **why it's important and how we can improve it**.

So I said that I'd talk a little bit about why some of the diagnosis was so late for me and my journey and experiences of having what I'm calling a hidden disability. For me it really was a hidden disability. Now I prefer to say it's a non-visible disability, because I don't want to hide it any more.

**The Equality Act from 2010** says that a disability is a physical or mental impairment that has a substantial or long-term negative effect on your ability to do normal daily activities. That is a broad definition. It encompasses loads of different types of disabilities which can be visual, hearing, learning, neurodiversity, physical, emotional and cognitive. All of that fits in this definition of 'disability'. It's important to note that in this definition, my hearing loss is classed as a disability.

But disclosure and identifying is a different matter. So it's important, everybody's lived experiences are different. If you were to speak to me when I was 16 and told me I was disabled, to be really honestly, I would not have liked that at all. Now I'm very proud about it and it's important to realise those nuances. This definition here is used to help us get support. But you know, identity of being disabled and disclosure is a different topic and you really should talk to the person involved and their lived experience as well. Lived experiences are really, really important.

**When we talk about disability, there's often three models that you might come across.** And I've summarised these models. You can find loads of research on this. And if you are interested in the different models, please come and I'm happy to share some references with you. The medical model, you can probably see from how I've summarised it, is not one that I'm a fan of. So the **medical model** says that we are the problem, that the disability is an abnormality, and it's purely a medical problem and that you have to fix ***us***. So, nope, that's enough time on that one.

So, **social model**. OK, social model. This is completely different. This says that we are disabled by society. So it's a condition created by bad design. So it's the barriers that's disabling us. Not us, we're fine, we're great. It's the barriers that are disabling us. And the **cultural model**. This is saying that disability is a vital part of human diversity. So it's recognising identity as disability and the diversity between lived experiences and the diversity amongst different groups within disability as well.

All of these models have their pros and cons, and I'm happy to discuss what they are in the questions as well. But what we're trying to really champion at Manchester with the Disabled Staff Network, also with other ones I'm involved in, Tigers in STEMM and the National Association of Disabled Staff Networks, is **the social model, that that should be a starting point**. Also we should celebrate disabled people and the amazing contributions that we give to society, but we need to address these barriers as well.

Specifically thinking about non-visible disabilities now and pros and cons with this. **So when I was younger, I did feel some pros to having a non-visible disability.** I felt a little bit like I could fit in with the hearing world, enough that I could hide enough, so I could kind of 'fake it, till you make it'. That, obviously, has a con with it, but I did feel that there was less overt discrimination that I experienced when I was trying to hide my disability. It is a shame that that was the case. But that's my experience, that there was less overt discrimination. And there was no assumptions about what I could do and what I couldn't do. But there was cons with that, so disbelief, discredit, 'You've coped before', lack of access to support, and lack of awareness and understanding.

So although fake it to make it, I don't think I could have kept that up. **So being open about it and open about my non-visible disability** was a choice to make sure that I got that support. And it needed it, as I went through the career I needed that support more and more. So let me show you some real quotes that highlight these as a pros and cons. And I'll read them out to you. So: 'She's too clever to be deaf. She should be a misbehaved child and not succeeding at school. Her hearing loss can't be as bad as the tests show'. That was from a consultant and that's why I had a late diagnosis. **So stereotypes are a massive problem.** A really negative stereotype about what hearing loss should be and what a deaf person should be like. A really negative stereotype from this one person meant that I didn't get hearing aids and get access to that till too late. He got fired, don't worry. So it is still a problem. So that is why we need to tackle this. It is a problem.

Dance teachers! 'How can you sing and dance if you can't hear?' I love karaoke. Karaoke is great because you know the words and how to keep in time. So. But, it is a thing that somebody decided that I couldn't dance ever and I couldn't sing.  I did get my dance reports out, and there was a lot of comments about keeping in time with the music.  But I was blissfully unaware. I was having a great time.  So why spoil that, why put that limitation on me?

And then colleagues: ‘Can't you just use your hearing aids?’ ‘I shouldn't have to change.  I don't need to use a microphone.’  How many times have we heard that one? Loads of things like that.  And even when you're trying to access things with HR and Access to Work.  ‘You're not that disabled, are you?’ ‘You're not that deaf, are you?’

Uff. Yeah. **But there's positives.  And this is towards the social model.** Alongside this as well was the opposite of that.  So my parents said to me all the time, ‘You can do whatever you want.  We will get your support’.

Another music and dance teacher within the same dance school said, ‘Don't worry, let's see how we can adapt the music tests and dance to let you succeed.  There are ways, and we will change how we work’.  And I did make it into the English Youth Ballet in the end.  So just changing can let you do that.

Other colleagues: ‘Please use a microphone.  It's not for you, it's for the audience’. Having people be an ally is so important, championing you and saying that. ‘Please tell us your experience, tell us what you need so we can understand and learn’. And that is a tip for all of us.  We all have something to learn.  So just asking what do people need.  It will be different – let's forget about stereotypes, asking what that individual needs. HR: ‘What support do you need? Let us know and we will put it in place for you’.  That can be very workplace specific.

But there are good lovely people in HR and our disability support team that really listen and do it.  And this is a massive shout out to the National Association of Disabled Staff Networks, which I found at Manchester, who have always gone, ‘We're here for you’, and just listened.  So we can – you know, if we've had a bad day and things have got tough, talking to each other and listening and just being there. Not necessarily having a solution, but just listening is so important.

OK. [To Tim Soutphommasane] I'm sorry, I'm going put you on the spot. I should have asked you this earlier. **Can I ask you, what you think makes a good researcher, please?**

## Tim Soutphommasane

This is all very spontaneous. **I think a good researcher asks good questions, is prepared to try new things, new methods to innovate and hopefully they find the right answers.**

## Jessica Boland

Perfect.  Thank you very much.  That is great. Perfect, yeah. That is completely true. That is exactly what we need from a good researcher, definitely.  Can we have a hands up in the room please. **Who thinks that that is all you should need to be a good researcher?** Passion, asking the right questions, et cetera? It's not a trick question, I promise.  Who thinks that that's all you should need in an ideal world, that's all that should matter, right? I think that. Yeah, ok. Couple of people, OK.

**I think you've predicted that here are some unspoken requirements, though.** Yes, perfect. Because that is all that should be required.  But at the moment the system needs changing, and I think we would all agree with that. So at the moment there are some unspoken requirements and I am going to read out the list of what I think are the unspoken requirements and I want you to just think if they resonate with you as well.

- Is mobile
- Can lift heavy equipment
- Can reach the lab bench
- Has 20/20 vision
- Has supersonic hearing
- Has effective communication skills (the conventional ones!) – you'll see why I've put that in there later
- Can walk up steps
- Doesn't need quiet space
- Can sit for extended periods of time
- Can take notes quickly
- Has a great short-term memory
- Doesn't need to use the toilet
- Has no other external responsibilities – no caring, no children, no partner
- Can cope with tight deadlines
- Has endless energy
- Can work in a group
- Doesn't need to take time off
- You can change topic easily, if there's a new funding thing you can just change topic like that
- Can travel easily – can travel internationally easily
- Can think all of the time
- Can keep quiet when appropriate (I struggle with that one)
- Is a native speaker
- Has no dietary requirements, medication needs, or adjustments
- … and (risqué one) Is White, male and from Oxbridge

**So, which ones do I struggle with?** So some of these, I think, probably all of you probably looked at that and went, ‘Actually, I really struggle with one of them’. And some of you might be sat here feeling like ‘Oh, I don't consider myself disabled’, and this is a point: that accessibility is not just for disabled people. It's for everybody. If we changed all of these things, I think we'd all be a lot happier. So **accessibility is really important because it does benefit everyone**.

So there's a lot of these that I struggle with. I can't lift heavy equipment. I can't reach the lab bench. I can now that I've changed it all. But my previous lab was for someone who was 6 foot and above so I couldn't reach the lab bench.

Obviously, I don't have supersonic hearing, but lipreading is pretty useful. And I can communicate, but not necessarily conventionally. I might need you to go slower for me, change the pace. Sometimes I might want to do it in sign language. I need sign language interpretation, and I'm starting to need that more and more at conferences as well. So I can communicate well, but not maybe in the conventional ones that is needed in an academic environment. I definitely can't take notes quickly. You should try lipreading, watching an interpreter and taking notes. It's just not possible. It does get you out of taking minutes.

So. ‘Has endless energy’. I probably look energetic, but after a day of lipreading and interpreting and listening, I am not, and I can be very grumpy. Then I can't work in a group. And also if I am working in a group, I need that to be effective communication, for example.

‘Can travel easily’ is getting more and more difficult now. Because when I fly, I lose my hearing for about a week, which is really annoying when I go to a conference. So travelling with long flights is now getting harder, and I need to change and have access for that. So that's getting harder and harder.

Obviously I need adjustments. And I have noted that although I am not male, I do now – I'm White and from Oxbridge. And I think it's also important to notice the privileges that we have and recognise that as well, that we need to listen to a range of diverse ideas. My experience will be different to somebody else's. So it's important to recognise that in yourself as well and also get that range of diverse experiences.

And all of these unspoken requirements, this is a shout out to Nicole Brown and Jennifer Leigh. So please please please, if you can, **there's a book**, and I will write down this citation and give it across, so it's a book called *Ableism in Academia: Where are the Disabled and Ill Academics?* And it's a really really fantastic book. And if you would like it, I think it's also available Open Access as well. So really really good to check out. And that talks about this unspoken requirements that I kind of summarised here.

What are we doing about it?

What's already in place in higher education? We already have current charter marks. (Oh! Thank you! It is open source, I have had confirmation. It is open source, so please do read it.) So what we have already got is a lot of current charter marks. I have some of their logos here. There's Athena Swan, Race Equality, Stonewall. **But when we come to disability, something specific to higher education is missing.** We do have some things: I've got the logo here for Disability Confident Employer, Business Disability Forum, Time to Change for mental health discrimination, and Access to Work. But there's nothing really that looks at higher education and research.

**And there are groups trying to champion this**. And I've put some logos up now, and I'm going to talk about some of them. So NADSN I've mentioned a couple of times, which is the National Association of Disabled Staff Networks. It's led by the fantastic Dr Hamied Haroon, who is a wonderful person and an amazing advocate. He's really leading that and he started it and founded it. And it's a group nationally of disabled staff networks that support each other.

Chronically Academic as well, specifically focusing on academics, again offering their support. The EDIS Symposium as well, again looking at issues in academia. Academic Mental Health Collective. The American Astronomical Society Accessibility and Disability. America is way ahead of the UK. We need to catch up. They're really on best practice in accessibility. There's lots of resources and the UK needs to listen and pay attention and get on it. And Wellcome Trust.

So there are people working on this. **And I'm going to summarise just a couple of projects.** And all this information I'm happy to give people afterwards as well. Specifically for science careers, which is passionate for me, the lovely Professor Gareth Pender and Professor Kate Sang at Heriot Watt are working on the Disability Inclusive Science Careers Project. This project has asked people working in STEMM 'What challenges are you facing?', to get that data there. And I've pulled out one quote which is **'It's like having a second job'.** Quite damning. The amount of workload is like having a second job.

**There's also a lot of work going on with BSL**. We've had some fantastic BSL interpreters today, who have coped perfectly with the science signs. But science signs is difficult, especially when you're creating new terms like 'topological insulators'. There is a group (I know, it's difficult!), a group called the Scottish Sensory Centre, who are developing a BSL glossary. It is really fantastic work by Audrey Cameron, Gary Quinn, Rachel O'Neill and Sheila Mackenzie. Please do check that out afterwards. This is something I'm quite passionate about: there are people making sure that everyone can contribute in STEMM in academia.

**And also Tigers in STEMM.** We do have some travelling Tigers in the room. So Tigers in STEMM as well don't just look at disability, look at all aspects of diversity, and have worked to create reports. And there was one specifically on disability, called *Accessibility in STEMM: Barriers Facing Disabled Individuals in Research Funding Processes*. This used lived experiences from the community, through NADSN, to pull together the issues specifically on research funding and put recommendations towards those research councils.

But some of the really interesting facts that came out from that was, **disabled researchers in STEMM fall, from 40% from undergraduate to postgrad**. So there's a drop off of 40%. And when we start looking at academics, from HESA data, there's only 4% of us that are disabled. And that's also all disabilities across all academia, not just STEMM as well. So there's a lot of work that really needs to be done. And I am not surprised at that drop off. Because the drop off in access is a major thing. As students at undergrad, there's quite a bit of support there, probably because you need our tuition fees. I'm very sorry to say that, but there is a focus on that. And when you start to become a PhD student, mmm, there's not so much economic financial incentive to support any more. And when you get to staff, again, it's a different kettle of fish, if you like. It's a different scenario, it's now funding from government, etc. So the support drops off. And that's one of the reasons I think that we have this leaky pipeline.

So, there is also a recommendation project from NADSN that I'm involved in. And there's loads of people within this organisation and **STEMM action group**. This particular recommendation project, there was a document that was led by Hamied, Julia Sarju in York, Jennifer Leigh in Kent and Yota Dimitriadi in Reading. And this is again lived experiences, trying to come together and recommend how we can go forwards with research councils and barriers, and it's all based on lived experiences. So this is a call out to people online and in the room. Please, get in touch if you would like to contribute to this. It's asking you, what do you think about research, what are the barriers, and what recommendations would you like to see, based on your experiences.

**So if I said a quick three things that we could do to help, is again, smaller, faster and smarter.** Let's **reduce that workload, that feeling of having to have a second job**. That's so important. Help people get that access, so that we reduce that workload so people can contribute and focus on being amazing, doing cool research, contributing to society and economic – and the economy.

Faster – **get that quicker support in place**. I would challenge that we shouldn't have to ask for it, it should already be there. And that was one of the fantastic things about this event. On the invitation I got, it had already said about BSL interpretation and captioning, and I wasn't going to say no then, because it was there and it was in place. But that is really, really best practice, and it's not everywhere. So have that access so we don't even have to ask, it's already there.

And let's be smart about it. **Let's learn from each other and let's share best practice**. While we do that, **let's celebrate disabled people**. And here I've got a logo of the organisation called Purple Space, and an advert for the International Day of Persons with Disabilities, which is the 3rd of December. So for this, this is a campaign to light up everything purple which is the colour of disability, to really celebrate disabled people. Now I don't know if we do this at Oxford. And maybe this is something you can help with. Of a purple light up. We recently started it, thanks to Kathy Bradley and the Disabled Staff Network at Manchester, we lit up Manchester the past two years to really show this. So that's something we can do, 3rd of December, all of us really celebrate people with disabilities. The Royal Society have also recognised it's important to have role models, to make people feel included and make sure that we can see people succeeding and there isn't those barriers, and Hamied's on this as well, and the lovely Daisy Shearer as well.

So, **celebrating scientists with disabilities, advocating for this, highlighting people in your organisation, really showing it off**. **And inclusivity is important and I just want to show you why.** On this slide I've got an example that was taken from a lecture slide. You can ask me why this is a picture later. It was a topic of electronic materials. It doesn't look anything like that. What it is, is loads of different students sat on seats. And if you look at the different students, hopefully you will see diversity there. There are students of different gender, of different ethnicity and different age. And also a giraffe for fun because it's my favourite animal. But even something as simple as that can make people feel included.

**People need to see themselves represented**. And the reason inclusivity is important is because we want people to succeed. These are two quotes from the surveys in this that I – really meant a lot to me. The first one is: 'As a disabled person (with a physical disability), the use of sign language made me feel more seen and able to be an engineer'. We have a shortage of engineers in the UK. We need to let people succeed. And this second one is really showing that accessibility benefits everyone. So the second quote is: 'The incorporation of sign language was really helpful, as a kinaesthetic learner putting actions to key words and topics helped me to remember them more'.

**So accessibility is great.  It doesn't just help disabled people.  It will help everyone – so let's do it.**

What can we do?

Some ideas to take away from this.  **You can start a reading club**.  Start by reading Nicole Brown and Jennifer Leigh's *Ableism in Academia*.  Learn, speak to people, get training as well.  We don't all know the answers. There's a lot of **guides out there for good practice**, try and find them and have a look, and also if something has worked well for you, discuss it with the community and share.

**Try and ask ourselves as well if we're providing equal access to all**. Could someone enter your lab, could someone enter your lecture theatre and not have to ask for anything? Is it accessible from the start? That's the standard that we need. It's not about minimum standards. We need to go beyond minimum standards, and that's how you're going to get inclusion.  So can someone turn up and it's already accessible for them? And that's the social model of disability.

**It's okay to make mistakes**.  I have made several mistakes and am constantly learning.  And that's the point, that you can get it wrong, but you need to learn from them.  So it's okay, and if you're unsure, ask.  Learn from someone's lived experience.  Just ask people and they'll be happy to tell you and you can learn from that.

And this is my final slide and my final word.  This is quite a common picture that you may have seen before. It's a poster that's demonstrating **equality versus equity**. So for equality we have three people of different sizes and they're all stood on the same box.  And they're looking over at... oh, is this baseball? Is this baseball, yeah? A baseball game. I don't do sport. I was going to say football. I'm glad I didn't say that. A baseball game. Ok. So they're trying to look over the fence at a baseball game. Obviously the tallest person that's standing on the box, he's having a great time, he can see all of the game.  The person who's medium height is holding on to the top of the fence. They can just about see but it's hard, they have to be on their tiptoes to look. And then the smallest person can't see anything at all.

We've given them all the same thing, so it's equal, but obviously they cannot access it in the same way.  On the other side we have equity, the same three people. Now the tallest person, he doesn't need a box so we'll take that away. For the medium person he's got his one box he's happy, and the person that can't see we've given two boxes, so they can now see.  That's equity.  They can all see the baseball game.  **So when we're thinking about accessibility, we're going for equity not equality.** And that's my final thing to say and thank you for bearing with me and listening to me for so long. Thank you.