>> Welcome to the podcast series of Raising The Bar: Sydney. Raising the bar in 2019, saw 21 University of Sydney academics take their research out of the lecture theatre and into bars across Sydney, all on one night. In this podcast, you'll hear Murieann Irish's talk, a world of pure imagination. Enjoy the talk [applause begins].

[Applause]

>> All right, thank you so much Finn, and thank you everyone for attending tonight. And it's a bit surreal, and I hope I can do justice to the Raising the Bar event. So, first off, I should preface this talk by giving a bit of a confession. So my name is Murieann, and I'm a daydreamer. Any chance I get, I lack off, and I start thinking about other things, other places, other people, other times, and when I was a child, I had an imaginary friend. And if anyone saw my Tweet earlier, I was saying what is a Byroni [phonetic spelling]? Well, Byroni was my imaginary friend. And so when I was young, I used to go out into the back garden of our house in Wexford, in Ireland, and I'd stand on this mountain of muck and the mountain was Byroni. And I just talked to Byroni, tell him stuff. My older brother thought that I was talking to an imaginary man inside the mountain of muck, but actually I was just talking to the muck. The muck was Byroni. And obviously, my parents didn't think this was too troublesome, and I turned out okay, but we had this lovely friendship that lasted just for a brief period. So just one Irish summer, so like two days [laughter], and I still look back and I think about standing on this mountain of dirt talking to Byroni. And so now I have a little boy whose name is Fjon [assumed spelling], and he's 5. And around about the time that he was 3, and his language started to become more sophisticated, Fjon developed an imaginary friend. And so just around the same time as he started being able to communicate in a much more complex way, this bear moved into our house and his name was Buddy. And Buddy was really rude. He was obnoxious. He was hitting us, he was calling us names, and he was getting away with murder. So Buddy was doing all the things that Fjon was not allowed to do, and being pretty much a pain in the Buddy. And so then when Fjon went to school, Buddy became less important to him, and he has since receded into the background. He comes out every now and then, and we love that. And so Byroni and Buddy. Why would our amazingly complex brains have evolved to enable us to create these weird and wonderful confections. So, in this talk, I'm going to try and get to the bottom of imagination. So what is it? Why do we have it? Is it unique to humans, or do other species perhaps have some form of imagination? What's going on in the brain when we are imagining? And why would we have evolved to have this capacity? And I'm going to try to get through all of that in the next 30 minutes. So, as Willy Wonka said, "So much time, so little to do, wait a minute, strike that, reverse it." So, when we speak about imagination, what do we mean? So we know that imagination is the sidekick for artists. It's the fodder of invention. It's the kind of essential ingredient for artists, scientists as well. We need it to innovate. But what is it? So the philosopher Emmanuel Kant described imagination as a blind but indispensable function of the soul, without

which we should have no knowledge whatever, but of which we are scarcely even conscious. And I think that's a great description of what imagination is. It gives rise to myriad forms of knowledge, but we actually don't have a good handle on what it actually is, or how we engage in this capacity. And it can take the form of many different things. So, on a very basic level, we can imagine something that's just not physically present. And this could be an object, or a person, or a scene. So I can imagine my two children at home, in their beds, hopefully asleep. But we can also use our imagination to combine items together, to create something that never existed before. We can take ourselves off to fantastical worlds. We can invent and create. And so clearly, there are many different types of imagination ranging from the rudimentary all the way up to something very sophisticated. So I've been watching the development of this internal world in my little boy, Fjon. And around the time that he was about 3 years old, he started commenting that he could hear music in his mind. It happened to be the theme tune to Paw Patrol. And so this is actually the start of a very sophisticated ability. And it forms the basis for us having an internal monologue. So us being able to think of our thoughts inside. And you'll notice that children stop talking out loud, and actually start talking and rehearsing things internally after this pivotal milestone. And thankfully, his musical tastes have since evolved from Paw Patrol and Wiggles, to something a bit more along the lines of Nirvana and The Clash, although that makes for interesting requests at day care. So around about the time when he was 4, he started telling me all about his dreams. So he started having incredibly complex dreams that he would remember the next day, and he would recount all of these different fantastical things that he had been dreaming about, with great gusto, the next morning at breakfast. And it seemed that bits of his everyday experiences were becoming interweaved into these dreams, and being recombined in new and novel ways. But now that he's 5, a seismic shift has happened in his cognitive capacity. All of the ingredients are now there to allow him to invent, to create, to imagine and to predict. And so now he's coming up with extremely abstract forms of thinking. So, he asked me the other day, who was the first baby [laughter]. And like, do numbers ever stop? How do I get married? What do I do when I get married? Do I kiss them on the cheek? Or do I have to kiss them on the lips? So he's going ahead in time. He's thinking in an abstract way. And he's really starting to think deeply about different things, which makes for very awkward conversations in my house at the moment. So he's going beyond the immediate. He's starting to anticipate, to predict, and to invent. And so, on any given day when I come home, he might ask me to be a jewel thief, a robber, just play mommies and daddies, be an underwater explorer. We're doing all of these inventive forms of role playing as his imaginative capacity is developing. It also prompts the first existential crisis. So, at this point, he's now realising that things are not fully under his control. So he's been asking me about baddies, and robbers, and what would I do if there was a robber in the house? Then he's gradually thought ahead to the future, he's looked beyond marriage, and he's realised that at some point, he's actually going to die. And so this has been quite a bit of grim, a grim realisation for a 5-year-old. But that blip

aside, he is now capable of doing an immense range of sophisticated and sort of recombinatorial capacities. He's inventing, he's creating, he is coming up with stories. He's drawing incredible pictures. And it has really broadened the world that he has at the moment. So thinking about all of this, I mean, it begs the question of what's going on. What underpins that seismic shift in his cognitive capacity? And for those of us working in the cognitive neuroscience of memory, we know that when memory develops, so too does imagination. So the two functions are actually on the same neurobiological trajectory. They emerge in parallel. They rely upon the same brain system. They decline similarly in conditions such as depression, Alzheimer's disease, and they're supported by this incredibly complex network in the brain called the default mode network. And so, we know that this network comprises multiple regions. All are in the brain. They all work together. They fire in concert. Whenever we're engaging in very complex activities, such as remembering, imagining and thinking about the thoughts and feelings and perspectives of other people–so when we're doing social reasoning, and the discovery of the default mode network, even though it's a huge topic in cognitive neuroscience, it only happened relatively recently and it was quite a serendipitous discovery. So traditionally in neuroscience imaging tasks, participants would do a task, they'd lie in the scanner and complete a series of trials or runs, followed by a rest period where you'd simply stare at a fixation cross while you're lying quietly in the scanner, and this was supposed to be a rest period, where you weren't engaged in any activity, that you could use then to control with your performance on the task during the experimental runs. Or so we thought. But actually, people who then went back to look at these rest trials, so experimenters actually found that the brain is not idle during these rest trials at all. And so if you've ever been in a scanner, doing a task, and you get a period to relax, what are you thinking about? You're thinking, God, it's noisy in here, am I dong okay? Have they found anything? Is my brain okay? I'm hungry. What's happening next? Your brain is constantly on the go. It's just that you're not focussed on the task anymore. And so what the experimenters found was that during these periods of rest, the brain was highly active, and in fact, the activity was pretty much similar to that when we're engaging in deliberate acts of memory, imagination, and social reasoning. And this makes sense, because at any given time, when we're daydreaming, most of the content of those thoughts is either a memory, is thinking ahead in time, or thinking about somebody else. So this discovery of the default mode network actually changed the whole way in which cognitive neuroscientists approached studying the brain using functional neuroimaging. It meant that we couldn't rely on these rest trials as an index of passivity, but really there was something going on when we weren't otherwise engaged that meant that the brain was highly active. And so it's ushered in this whole new set of studies. There's been thousands of papers since this discovery, trying to find out what's the architecture of this network? How does it serve us in health? And how is it compromised in disease? So it seems that the modus operandi of the brain is perhaps a default mode, where we're thinking, planning, ruminating, anticipating, and thinking about others. And this is one of the pivotal discoveries and capacities that humans have. If

you think about it, if you're sitting in traffic, and you're stuck in a traffic jam, you're most likely to probably drift off and start thinking about maybe your day ahead, wanting to get home, thinking about what somebody said to you, or what shoes somebody else wore. You're constantly thinking about different things until an external stimulus prompts you. So someone might toot their horn to remind you, you need to go. And so there's an alerting stimulus that brings you back to focus on your current surroundings. Or, I'm sure we're all familiar with sitting through a really boring talk. I hope not this one [laughter]. And where the speaker is not engaging you sufficiently, and you willfully take your attention away and start to think about something that's more interesting. And we've all been there. So this is basically saying that the brain has a mechanism that enables us to simulate something that's much more stimulating when your current environment is not up to scratch. And that's a huge evolutionary leap forward, if you think about why we might have had this capacity and why it has developed in terms of an evolutionary adaptive value.

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>> Okay, so prior to coming here this evening, I had my own imaginative crisis in the taxi. So I was running late, and I was panicking. And I had never done one of these events before, and in fact, I'd never been at this venue before, so I started trying to simulate, to try and make myself get adjusted to the situation I was about to face. So, I've given a number of talks before, but never in a bar. But have been in a bar or two in my day. So, I was able to put together a reasonable spatially integrated scene that I could start to populate then with different details. And so I imagined the bar, I imagined myself up at the front, possibly being blinded by lights, because that had happened to me at previous occasions, and think I was, I was accurate in my prediction. And also then I started playing around with the scene. So I was thinking, well I could look out across a sea of faces, hopefully I'd see some familiar, friendly faces. I could see someone at the back there. And also I could start to put in different things that may be less likely to crop up in this scene. So I could imagine my parents being there, but they live in Ireland, so that's unlikely. I could imagine being pelted by tomatoes by the audience, which I hope is unlikely, or I could imagine something completely implausible, like maybe a crocodile walking across the frontier. So, we can build up very likely scenarios, but also we can populate them, and play around with them, and change the way that we envisage certain outcomes, and all of this depends on the default mode network. So, if somebody had scanned my brain while I was there, ruminating and thinking ahead, and anticipating this talk, they would have seen that the regions of the default mode network were highly active. Especially regions that we know that are particularly crucial from memory. And one structure in particular that we know is absolutely essential for the encoding and storage and retrieval of memories, is the hippocampus. So this is a seahorse-shaped structure that is located deep inside the brain in the temporal lobes. And because I was drawing on my past experiences of previous talks that I've given, as well as trying to integrate details into an event, the hippocampus would have been highly active during this time. And so it has

been proposed that perhaps the hippocampus is actually a crucial relay station that supports the binding of different details in high resolution, and enables us to remember, and to anticipate and construct spatial scenes. We know that when we remember past events, the hippocampus is highly active, and so too it is when we are envisaging the future, and in fact, if I showed you two scans, one of a person remembering a past event, and one of them envisaging the future, you would be hard-pressed to tell the two apart based on their patterns of activation. So the two operate from a very similar neural network. So that's the neurobiology of imagination. But I guess the crucial question for us to ask is why do we have this capacity? What would be the evolutionary benefit of not paying attention to your external environment? Surely it's better to stay focussed on your immediate surroundings so you don't get snared by a predator, knocked down by a car, so you can be on the alert for resources, access to food and mates. These are the evolutionary imperatives that we should be paying attention to. So at its core, it has been suggested that the evolution of imagination relates to problem-solving. So, if you think for a moment about how important it is to be able to anticipate the outcome of your actions without engaging in a costly behaviour, you know not to walk down a deserted dark alleyway at night in a bad area of town. You don't need to get mugged to realise that may not be an adaptive behaviour to engage in. So, to imagine the possible consequences of actions conveys a huge survival advantage, and this is something that our ancient ancestors must have had to enable them to adapt, and to evolve, and to be more adaptive and to survive. And this is particularly important. It has been suggested in societies or in groups where there's a strong social element. So we know that some of the great apes who live in social cultures, they can also demonstrate rudimentary forms of imagination. So they've been able to adapt to tool making, and to invent new ways of solving problems, and these may seem like rudimentary forms of imagination, but actually these are the very skills that our ancient ancestors first developed, and from which we have evolved today. And there's even evidence to suggest that these rudimentary forms of imagination may have given rise to foresight, which is our ability to think ahead. And as humans, we are quintessentially a forward-looking species. We are constantly looking ahead in time. In fact, it has been estimated that half our waking day is devoted to thinking, planning, anticipating, predicting. It's all very future-oriented. And so we know that some animals actually have a capacity in a very rudimentary way to engage in a future or sort of prospective oriented behaviour. So there are food catching birds, Corvids, who we know can actually store food, come back to it at a later date, and even modify the amount that they store, depending on the local environmental conditions, anticipating perhaps what might occur next. So, again, a basic form of prospection, with huge survival advantage. And in humans, it has been suggested that having this capacity for foresight, they've heralded in some of the great ages of humankind. So knowing, for example, that if you planted a seed, you would need to return to where you planted it, and to wait a certain time before you could actually harvest the fruit of your labour. And they're saying that perhaps this ability to cultivate this patience and to return to the planting of a seed, it may have been

the antecedent of the agricultural revolution. So, taking that leap into a future or prospectively oriented form of thinking, with again, huge survival benefit. So our very survival hinges on us being able to think ahead. We need to be able to anticipate, to predict, and to adapt our behaviour accordingly. It has been suggested that in fact, and as I alluded to earlier, some of this imaginative capacity may have evolved as a spinoff of another cognitively evolved capacity. And one of the candidates for that is language. And so, as I said, my little boy started using his imagination in a much more sophisticated way as his language developed. And so it has been suggested that if we're able to communicate our ideas in a more overt way, it actually gives rise and lends itself to us being able to combine ideas together in new and novel ways. It's a much more efficient way of being able to relay information and perhaps recombine it. And so this all makes sense if we think about trying to relay information between our social–different social groups and changing environmental contexts, to ensure the best survival, and the best outcomes for you and your kin. So basically the brain is trying to make things as predictable as possible. The brain doesn't want us spending time, hemming and hawing, and trying to make, you know, costly decisions. It wants us to extract essential information to deploy it in a way that is best for our fitness, and our evolutionary adaptive value. But it's clear that humans have taken this capacity further. So we're not just surviving, we're thriving. We're flourishing. We're creating, we're inventing. We're using our brain to think about a much higher order construct, like science, art, philosophy, the brain–we're using our brains to think about the brain, so it's all very meta. But what type of imagination actually facilitates this synthesising of ideas to create something new? This is sort of the holy grail of imagination is to have a breakthrough, to be creative, to bring ideas together in new and novel ways. And some people would hope to turn a profit in the process. And so it seems that this form of synthesising different elements to create in a truly unique way is a much more recent evolutionary phenomenon, and it has been dated back to approximately 35-50,000 years ago. And it has its origins, some say, in depictions of some of the earliest forms of art. For example, in some of the caves of southwest France, show that there are creatures depicted in this art work that could not possibly have been seen by the creator. So these figures are half animal, half human. So they could not have been encountered in the person's daily life. They could never–would be encountered, either, in their lives. And yet, there was a synthesising power to bring together different elements to create something new and novel. And so it has been suggested that some sort of leap has occurred around that evolutionary time that gave rise to new and highly adaptive forms of imagination. And so people have suggested that again, this may be a powerful driver of creativity, and it appears that again the synthesising power to move across disciplines is probably the most sought-after capacity that humans could have, and if we look back through the ages, there have been very few who have managed to do this with great success across different disciplines. So one such person would be Leonardo da Vinci, who was the master at extracting patterns in nature, but applying them across disciplines. Some have suggested that Steve Jobs was a modern-day example

of this, because he was working at the intersection of technology and art, and he believed that the intersection of those two was where true innovation lay. What are the conditions necessary for creativity? So how do we achieve a Eureka moment? And again, if we look back to some of the seminal discoveries or breakthroughs through the ages, we can find some clues. So most of these discoveries have come from individuals working and being immersed in a period of time, working on a problem chipping away at it, and perhaps having a hunch that something was going to emerge. And it seems then that there's a willful withdrawing from the problem, and a period of quiet contemplation. So, for example, Isaac Newton was immersed in his studies and decided to go and sit in his garden and sip tea after dinner, and he was in contemplative mood, when he noticed an apple falling from the tree, and thus, the law of gravity was born. The physicist, Richard Fineman, apparently was taking a break and watching students mess around in the college cafeteria. They were spinning plates. And he decided, for fun, to calculate the wobbles of the plates. And this led to the Fineman diagrams, which ultimately resulted in a Nobel Prize. And so we also have examples from not just science, but also literature. So one of my personal favourites, in terms of children's authors, was Roald Dahl [assumed spelling]. And so he was one of the great creators of these vivid and evocative descriptions of absolutely grotesque characters, and amazing creations like the Chocolate Factory that Willie Wonka ran. And so he had this knack of withdrawing from the external world, and he had a writing hut, where he would go to achieve this. And so he said of this writing hut, "When I am up here, I see only the paper I am writing on. And my mind is far away with Willie Wonka, or James, or Mr. Fox, or Danny, or whatever else I'm trying to cook up. The room itself is of no consequence. It is out of focus. A place for dreaming and floating and whistling in the wind, as soft and silent and murky as a womb. It's such a powerful description, so he's not even in the room. So he's off in his own imaginative world. And that's what gave rise to these fantastic characters and creations that he so readily was able to create. And another more recent example, I'm sure you're all familiar of the tale of a daydreamer now billionaire, who used to work at Amnesty International and had an idea rolling around in her head for quite some time, but never could quite catch it. She just had this hunch of something she would like to do. The train was stuck somewhere between London and Manchester. She was stuck on the tracks for a couple of hours. Everybody else scrambled to get their laptops, and to catch up on Excel Spreadsheets, and work demands for the next day, and she stared out the window for hours, and it was during this time that the entire plot of the Harry Potter series simply fell into her head. So this was J.K. Rowling, who credits the Harry Potter series with active daydreaming and disengaging from her ongoing work. So it seems that we need a period of immersion on a project, but also quiet incubation, where we actually take our attention away from the problem that we're labouring on, and allow the default mode network to do its job, to let the ideas come together, almost in a collision of different thoughts, different actions. They come together in new and novel ways, and that is the food stuff of creativity and invention. So the philosopher, Bertrand Russell,

noted in a famous 1932 essay called"In Praise of Idleness," that humans would be well advised to adopt a four-hour workday, ensuring more leisure time for all. I think it was a pretty good idea, I really do like that Bertrand Russell [laughs]. So, up to this point, we've been considering how imagination might help us to thrive, how it serves us, how it gives rise to some of these amazing feats that are unique to humans. And as Bertrand Russell said, daydreaming enables us to cultivate possibilities, so to imagine the possibility of a better world, and he said that this could lead to cultivating art, science, culture, even liberating the oppressed, and instilling democratic governance. This may be so, but it's a sad fact, that in fact many of the atrocities and the horrors that humans inflict on each other are a direct product of human imagination, and so it has begged some to question whether we should invest in imagination. So should we be schooling our children to deploy their imagination in a morally sound way? Or would we be better off without it? And I think in a sense, we can address this question, by thinking about what it would be like to lose the capacity to use your imagination. And so for many years, this has been the basis or the crux of the work that I do at the brain and mind centre at the university of Sydney. I'm trying to understand what would it be like to lose your capacity to imagine? It's something that we take for granted. It comes to us so seamlessly, and so readily every day, and yet I don't think we really think about the complexity and the underlying machinery that's making this possible. There are huge individual differences in your capacity to imagine, and it's been discovered that there's actually a population of individuals, healthy, neurologically intact individuals, who never have experienced mental imagery in their mind's eye. And so this discovery has come as quite a shock to otherwise completely healthy individuals who, when taking part in a study or when discussing with friends, suddenly this idea that there's a thing called mental imagery and it's something they are bereft of, can come as quite a shock. And these ephantasics [phonetic spelling] are opening up new doors in terms of how we understand the individual differences in the imaginative capacity that are just naturally present across the human population. But an important aspect of my work has been to try and understand what happens to imagination and to memory in dementia. And so this is something I'm very passionate about, having watched my grandmother, who had an immense memory, lose her memories due to Alzheimer's Disease. And that set me off on a path where I just wanted to understand what was happening, why this was happening, what was going on in the brain, and what can we do? How can we help? What could we do to intervene? And so this has led me on quite a quest. I've been exploring memory, imagination, future thinking, all of these different sort of weird and wonderful ways in which the mind enables us to sort of transcend the here and now, and to understand what it might be like to lose these capacities. And so our research converges on a very stark but simple fact. When you lose your capacity for imagination, this essentially strips you of a sense of your future. So we have our patients presenting, who present with a loss of motivation, as sort of absence of what it might be like for them as a person or a sense of agency at a future time point. And this could seem quite abstract to all of us. We don't really think

about what it would be like if our future timeline was suddenly cut short. But it has been suggested that depression is actually the inability to construct a future, and in many ways, I think this is something that we would prefer not to think about. Because it's so at odds with us as continuing entities across a sort of subjective timeline. So, in any case, at the University of Sydney, we are trying to understand the neural mechanisms that are driving this loss of imagination, how it relates to disturbances in memory, and what can we do? How can we intervene? Are there ways we can provide external supports to enable the person living with dementia to live well and to live a more enjoyable life for as long as possible? So, coming back to imagination. I still have Byroni on my mind. I have Buddy waiting for me at home. I think as a scientist, we really need to cultivate our imaginations. Imagination to me is the crux of invention. It's the crux of innovation. If I can't see patterns in my data, if I can't stand back from the data that I have, and draw on ideas from different disciplines, and from different fields, then something is wrong. We have to be able to use our imaginations, to use the data that we have, the insights that have been gleaned from other disciplines, and to pull them together into something new and unique. That is the way that we will be able to innovate. That's the way towards progress. I think that we need to have skilled imaginations, and it's something that we need to actively foster in our children. We shouldn't be admonishing our children for daydreaming. We should be encouraging it. And we should probably be investing in and encouraging children to use their moral imaginations to imagine what it might be like if you did something to another person, and how you might feel as a result of that. So I think your homework for tonight is you are to turn off your devices, let your mind wander, and just see where it takes you. You'll probably start thinking about a crazy Irish girl standing on a mountain of muck, talking to the air. That's good. You're giving your default mode network a workout, and I think here's to Buddy and Byroni, they've gotten us to where we are today and so as Einstein once said, logic will take you from A to B, but imagination will take you everywhere. Thank you.

[Applause]

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