The Evolution of Creativity

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We want to try to understand why it is that we're a species that has gone from these very very simple pounding tools these are actually pre-human chopping tools way over on the left up through hand axes you know many of you will be familiar with those hand axes and then right the way through breathtaking art soaring cathedrals like the glasgow cathedral space shuttles driverless cars and iphones we have cumulative culture last night i said we're a species with a history when we look into the past the world was different for us we accumulate knowledge and skills and technology other animals have culture but no one has demonstrated unequivocally any cumulative culture in any other animal but humans and so we go to our close closest genetic cousins the chimpanzees with whom we share about depending upon how you measure it 95 to 98 or even more identity in the sequences of our genes they are sitting on the forest floor fishing for ants with pieces of grass or sticks and chopping nuts with with rocks the same way they have for millions of years so very very different from us they do not have cumulative culture and we want to try to understand what it is about us that has allowed us to achieve that cumulative culture while no other animal at least demonstrably has so that's our that's our question we'll we'll put those two next to each other we want to understand why we've been able to move in really a very short period of time because those hand axes are something on the order those particular hand axes would be something on the order of 40 50 000 years old to in that very short period of time having this technology that almost no one understands okay well the usual human conceit is that we can do this because we're we're clever and to take a sort of light-hearted approach um we would like to think we're clever but we know we're capable of some really really stupid things like grabbing a lion by the tail i don't know what that guy's doing um you know he's wearing something on his head he thinks is going to protect him that's even more evidence of stupidity um we also do things like we we paint lines on roads around trees i don't know this is not a clever animal that's doing this one of my favorite is that when you're driving i forgot which motorway it is it probably says on the sign when you're driving along the motorway there's this sign that says um secret nuclear bunker uh there you are um and and then perhaps you know the crowning one i'm well i think we're all capable of this so don't laugh too hard is these poor guys who hadn't figured out how to

spell stop well it it that's the light-hearted view of it but you know when we look at decision makers they're not so much better because um here's baseball coach casey stengel says never make about the future that's a really really good adage to follow but more seriously here's thomas watson the president of ibm in the 1950s and he said i think there's a world market for five computers and in that five actually he he added if the u.s government buys one so that was four really a world market but then the us government made it five um there's no reason anyone would want a computer in their home that was ken olson president of the digital equipment corporation 1977 now anybody who's younger than having been born 1977 won't realize the deck deck corporation went out of business they um they went extinct um he made the wrong prediction this is a really nice one poor old jk rowling children just aren't interested in witches and wizards anymore that was a publishing executive who returned her manuscript and then this is a really nice one it must be what it's from the 30s or the 40s the people who are looking at the wizard of oz saying take that rainbow song out you know take it out it's no good you know a song we all can can sing um from memory okay so so we we have achieved remarkable amount with our cumulative culture but at least on the face of it we're not as clever as we would like to think we are our human conceit is and a little bit more seriously we're continually asked to make decisions about things that we don't know the answers to so for example what pension should you invest in what insurance policy should you buy what car should you buy who should you marry these are really big questions in our lives and we generally don't know the answers to them why is that again if we were a really clever species you might have thought we could just come up with the answers to those things the same thing i mean sort of in parallel we're surrounded by technology that we make use of but we don't understand we couldn't possibly build ourselves in fact each of these pieces of technology takes teams of hundreds of thousands of people to make and no one of those individuals who's part of that team understands the whole product so there again doesn't look like we're an overwhelmingly clever animal and in fact if this is if this is sort of stretching the point because you're saying well yeah but nobody should be able to make an iphone on their own can any of you do this can any of you make a pencil well leonard reed an economist writing in 1958 a famous essay he wrote called i pencil he says in there not a single person on the face of this earth knows how to make me and you're all sitting there very sort of smug saying yeah i could make a pencil but can you do you know how to get iron ore out of the ground and then turn it into steel do you know how to make the factories that turn the iron ore into steel do you know how to make the machines that pull the iron ore out of the ground we're just on that little cap at the end of it do you know how to get latex out of trees do you even know where those trees grow and then do you know how to turn that latex into rubber do you know how to grow the trees and then cut them the proper way you know how to ship those trees across the sea to your factory here in glasgow to make your pencils you know how to extract lead and by the way who's going to make the roads that your cars oh and who made the roads who made the cars that carry the stuff or the lorries that carry the stuff so even a simple object like a pencil leonard reed's point was that not a single person on the face of this earth knows how to make me teams of people are required and teams of or or and and years of cumulative cultural evolution are required for us to even make something like a pencil so we can conclude from that really is a rather sorry state of affairs that most of us

are just glorified karaoke singers in most aspects of our live lives using things that other people have made singing their songs and i put it to you that you i'm going to set the bar rather high ask yourself you don't have to sort of say out loud because this could be a bit embarrassing but ask yourself if you've ever had a thought that changed the world okay well that does set the bar rather high have you ever had a thought that changed the way people in your discipline all did their work maybe you have have you ever had a thought that changed the way your family behaved have you ever had a thought about making a new recipe that was so good that a lot of people would want to adopt it creativity is really really really hard and i think if we're honest with ourselves most of us are these glorified karaoke singers in most aspects of our lives now again you might be thinking that i'm stacking the cards because i've been using all these modern examples but you should rest assured if you think maybe you are just a karaoke singer that it's always been this way so here is a hand axe an aboriginal hand axe i mean it's just a gorgeous object aboriginal handx from western australia now one time when i was in australia um i wasn't in exactly that part of australia but one time when i was in australia i had the great fortune to spend a lot of time with an aboriginal man who was still living traditionally and i had an interpreter with me and the interpreter said to me feel free to ask and and she she called him sammy so a lot of these people will take a sort of christian name so it's easier for people to to interact even through an interpreter so she said feel free to ask sammy a question and sammy happened to be building a hafted axe like that right in front of me he was making a hafted axe and as i watched him doing it i was thinking to myself well i wouldn't put the top of the thing on the on the handle like that i i would do that differently i was a little bit confused as to why he was doing it that way so i said through the interpreter i said ask sammy why he's putting the the chopping part on the handle that way and she actually asked him you can imagine sammy looked up at me and with this really perturbed look on his face like you know who is this western interloper who thinks he can do better than me he looked a very perturbed look on his face and he said because we've always done it that way now my point is that it's possible that sammy didn't know why he was doing it that way that he was a karaoke singer as well and that he was doing it that way because he'd been told to do it that way by his mother or his father or somebody in his tribe and they had been told to do it that way by somebody you know a generation before and so on and so on and so on now as i say it's quite possible he just didn't want to reveal his tribe's hard-won secrets to this interloper like me but i think we can entertain the possibility that he didn't even know why he was doing it that way and i don't want to pretend that i had a better solution i'm sure his solution was better than mine i was just confused okay so we come back to this question given that we don't seem to be as clever and as innovative as we'd like to think and that we might accept this idea that most of us are just karaoke singers doing what others have taught us to do laying down the tracks of our songs of life we want to know how did we get from those simple tools to this thing like a driverless car well as i say the usual human conceit is that if we just think hard enough about something our giant big brains will reveal the answer and i think this is the view that most of us hold about about human life and if we if we we wish we were cleverer it's because we think everybody else is going to brain the size of this guys and is just thinking hard about and we even you know we even represent this in public life as a light bulb going on don't we this is the light this aha insight this is the light bulb going on

so this is the idea that if we just think hard enough about something you know innovation is the view that we that we make progress in big revolutionary leaps we just think really hard about something and the solution will reveal itself to us but if we study the evolution of technology and this isn't me studying the evolution of but but sociologists economists historians of science over the ages studying the the evolution of technology a completely different picture emerges from this one of the big-brained person sitting and thinking hard about something so for example if we take a look at the the story we all know about james watt inventing the steam engine well it turns out that james watt the guy on the upper left there he didn't invent the steam engine he refined and built upon incrementally an earlier design of about 50 years earlier this is he's in the late 18th century by thomas newcomb henry ford is often credited with inventing the assembly line and the automobile and turns out that he didn't invent either the assembly line or the automobile or some people say interchangeable parts all he did was refine those things the ideas were already out there thomas edison is perhaps the icon.

he's the one that we all know about.

Thomas edison is the inventor of the light bulb but if we look at thomas edison's patent for the light bulb it wasn't for the light bulb it was for a better filament to the light bulb but the story doesn't end there thomas edison's own diaries record that he didn't just think hard about what to use as the filament for his light bulb he in his own notebooks records the following he says before i got through edison recalled i tested no fewer than 6 000 vegetable growths and ransacked the world for the most suitable filament material thomas edison inventor of the light bulb just searched the world and he tried everything and it's worth looking at his notebooks because he would just pick up stuff that was lying around in his house bits of hair bits of grass bits of string copper wire he'd just try everything as a filament and he finally hit upon something that glowed for about 15 hours and that's what he got the patent on all right you're all waiting for the final one steve jobs well steve jobs is our is our poster boy now we shouldn't talk about a man who died recently like this but he's our poster boy for innovation but some people argue in particular the xerox corporation argues that he didn't invent the point-and-click operating system that we all so happily use now but he was on a tour of the xerox corporation and he noticed their point-and-click operating system and he went back to his apple garage at that point and and and put it into action so that the xerox corporation actually took him to court over this claiming that he stole the idea from them but let's not take away from jobs because what jobs realized and this is going to be partly a theme of this talk jobs didn't invent that operating system the point-and-click but he recognized its importance and he knew how to develop it and market it in a way that the xerox corporation you know greatly to their dismay never did okay so that's a kind of tour really quick tour around technology but we don't have to stay in technology we can go to the world of art this is the this is the the richest living artist in the world damien hurst you all know him the the the sort of brit art of the 1990s and he he said very recently you can see was in the times 26 april 2018 not that long ago he says i spot good ideas and steal them he's bragging about it and sure enough um he the multi-millionaire artist that said in that article has admitted that all his ideas are stolen and he it's ironic he's standing in front of one of his paintings you know as one of his spot paintings and

he says i spot good ideas and i i steal them so no less than damian hurst richest artist so stealing is good makes him a lot of money i think he's worth four or 500 million something like that okay now let's not be unkind to august rodan but he used to go to the british museum and he called it his temple of muses he said he got all his ideas for the sculptures that he did from sitting around in in the british museum let's come back into the sort of more vulgar part of the art world um this chap i don't know if you any of you have ever gone jeff coons i don't know if any of you have gone to any of his art displays he makes these sort of garish things out of steel they're very very kind of bright and attractive he's he's copied the venus of villendorf with a with a um a kind of aluminium you know blow up balloon size version it's about this tall if you haven't seen it and very very recently um he was found guilty of plagiarism in paris in order to pay 168 000 um for stealing his ideas uh for that thing in the upper right corner and now why anyone would want to steal that i'm not sure but he he did okay so the art world is not free of this and even the great picasso himself said good artists copy great artists steal and then let's move on to science or natural philosophy the the fabulous um almost incomparable isaac newton was humble enough and we're going to grant him this conceit because i think he was a very clever guy he says if i have seen further is by standing upon the shoulders of giants okay so this is just a way of trying to knock us down a peg and now we're going to try to rebuild somehow and figure out how it is we've been able to achieve this great cumulative culture if we're really just doing sort of incremental evolutionary rather than revolutionary stuff and we're more inclined to steal good ideas than to come up with them ourselves okay so let's just pose a question and a big part of the rest of the talk is going to be just kind of speculating and thinking about things so why does there seem to be so little innovation in so much copying now keep in mind throughout the rest of this talk that we're a highly highly social species and this is gonna this is going to matter we're around each other all of the time so why does there seem to be so little innovation so much copying so i want to sort of imagine that you're a person on the on the savannah in in africa 40 50 000 years ago and there's a lot of stuff there that can kill you and wants to kill you and for you to stay alive you've got to kill it before it kills you or you've just got to be good at foraging for stuff that you can eat like pumps but while you're doing that you've got to prevent yourself from being killed by things that want to eat you and it turns out that if you think hard about it and i've just told you you're not very good at that but let's try it anyway if you think hard about innovation it's it's very very hard to do it's time consuming it's costly and it's maybe even dangerous now let's let's put this into into perspective here um how would you design a better spear so you're on the african savanna and you've got this spear and you're thinking i want to design a spear that i can throw further because i'm having to get too close to these lions that are trying to eat me but i also want to penetrate that animal's skin deeper what are you going to do how are you going to change your spear anybody know what the answer to that is you make it heavier how much heavier you make the you make the end of the stick pointier how much pointier do you make it it might snap if you make it too pointy what's the answer to it you can see that to know the answer to it you're going to have to know a lot about physics you're going to have to know a lot about the way things fly through the air you're going to have to know a lot about forces and so on and so on and so on so what would you probably do well if you didn't have somebody else to steal their best idea from you'd probably sit there like edison

just trying lots and lots of spears one hopes not on lions because they'd eat you in the meantime but on something else to see how it worked you would just go by trial and error and that's what i mean that innovation is hard it's time consuming it's costly in that the whole time you're throwing spears around trying to see which one's gonna stick better you're getting hungry and things are trying to kill you okay and it's dangerous so why innovate if you can copy others now this is a really really profound point even though it sounds simple that we're going to want to explore for a while because it explains a lot about us so i put it to you that it's very very difficult even just to design a better spear much less an iphone or even a pencil okay well this this question um came to um a really lovely guy and i think he's retired now um called alan rogers back in um what was it 1989 and he posed a thought experiment and he said let's imagine an island where the environment is sort of constantly changing not in any violent way but the environment is just constantly changing and he said let's imagine on that island let's we'll have two scenarios he said let's imagine on that island we had a society of innovators everyone was an innovator on that island nobody copied each other everyone innovated on their own to find solutions to things like what shelters to make what things you can eat how to design a better spear and so on and so forth and he said in that society of innovators beavering away what if a person arose who was a copier who just copied the innovators they wouldn't have to pay any of the costs of thinking hard the time the danger the probability of perhaps starving to death while the innovators were innovating away they would just copy the outcome of the innovator so in a society of innovators rogers realized copiers would flourish so we can put those arrows on there to say that in a society of innovators copiers would flourish they'd be on the rise and they would displace the innovators because they would be getting all of the benefits of innovation without having to pay any of the costs of innovation.

okay well you know where we're going let's flip to the other side let's imagine this same island now but everybody on the island is a copier okay well the copiers do find for a while they all just copy each other right but after a while the environment is changing so you need better solutions and it's also the case that when we copy we don't copy with perfect fidelity as we make mistakes and if i'm merely a copier i'm going to copy your mistakes and mistakes are going to get copied on top of mistakes and so on and so on so now you can see what's going to happen in a society of copiers the innovators will begin to flourish so imagine an innovator arises on that island they'll begin to flourish so then the question that is posed by this thought experiment is what happens copiers flourish in a society of innovators innovators flourish in a society of coppers copiers what is the balance between the two and what we want to investigate tonight is this idea that it seems like most of us are copiers and we're not very good at innovation so let's see how far this idea goes and see if we can use it to understand that what seems to be that puzzle about what we think is a really really clever animal okay well to to answer the question of where where the two meet um uh and because the the hint i think many of you i hope are are are realizing the hint is that it doesn't take very many innovators in a society of a whole lot of individuals most people can be copiers because as long as there's a few innovators everyone can copy them everyone can copy their best solutions and so really all we need is enough innovators to sort of keep up with the changing environment or to keep us on track if we make mistakes in our

copying so we can start to see the the the beginnings of the society of karaoke singers already but we don't really know where the two meet well in 2010 and it seems more recent than that because it's such a striking study um kevin leyland who's um just uh east of here at saint Andrews.

he undertook a great big computer tournament to try to answer the question of how much innovation is needed he undertook this enormous computer tournament in which he asked people from all over the world to submit computer programs that would exist in silico inside a computer where they could see the other computer programs and those computer programs had to solve a problem much like alan rogers um island with a changing environment and what what kevin leyland did was he erected what's called a multi-armed bandit which is a lot like a one-armed bandit this is all of course in inside a computer it doesn't actually exist but this multi-armed bandit had 100 levers to pull and the idea is you have to know which levers to pull at any given time to get the right outcome and you can imagine that that's uh those hundred levers you have to pull are a way that you're surviving in a complex environment and 100 isn't very many when you think about how complex our environments are just the decisions that you had to make to get here tonight okay so he he put up he he put together this in silico environment invited all these people he got 104 computer programs um and he he then competed them against each other and after uh zillions of of computer hours um he he found 10 that really out computed out competed the other 100 or so and um he allowed the programs to um have three kinds of moves they could they could observe another program they could innovate them themselves or they could um actually act they could do something he called that exploit now we're not going to worry too much about acting we're just going to assume that you either observe or you innovate that's all we need to talk about because they all acted in some way it turns out that acting quickly was important but that's not really what interests us tonight so we're interested in observing versus innovate so what's going to happen with these these computer programs so the program ranged from those that always innovated to those that always copied and these had been contributed by people from all over the world not on kevin's instructions kevin leyland's instructions just saying write a computer program that you think will do best at this task well i think much to everyone's astonishment the winner copied virtually 100 percent of the time the winner of this multi-armed bandit tournament was a computer program that copied at least 95 of the time it almost never innovated a strategy that nearly always innovated finished last in those computer um in the in the computer codes and here's a plot uh on on the left there that shows the um the sort of scores that your computer strategy got uh as a function of the proportion of times you observed that as you watched others and you copied their moves and you can see that the more you watched others right up to 100 percent of the time the higher your score was so these computer program the computer programs that watched others and did what they did were the ones that did the best and here on the right this is a little bit difficult to read and i apologize for the the quality of these it's just the nature of the reproduction from the the journal in which this was this was published is you can see on the on the x-axis on the horizontal axis what kevin is plotting is how changeable the environment was and so on the left the environment isn't changing very much and on the right it's changing a lot and you

can see that the advantage of copying because the the red circle strategy is the strategy that won the tournament as as the environment becomes more changeable the more it paid to copy others rather than to innovate so basically the harder it got to know what the answer was the more it paid you simply to copy others so this is a really striking result that uh surprised um kevin leyland considerably and and really went around the world in in the world's media okay so why does copying work well there's a really profound realization as to why copying is such a good strategy copying works because innovators must show their best strategies so if you're an innovator and you've come up with some good solution you don't stop using it you've got to stay alive too so innovators must show their best strategies and two by virtue of being available to copy that is by still being alive the strategies of the innovators have proved successful in the past so when you're living in an environment in which your decisions matter anyone around you who's still alive has been making a series throughout their lives of non-fatal decisions so each of you who's here tonight has never made a fatal decision and none of your parents ever made a fatal decision right and that is why copying innovators and copying in general is such a good strategy so what kevin realized from his his his grand tournament was that few innovators are needed or could even survive because they are parasitized by the copiers so copying pays because innovators have to show their best strategies and by virtue of being alive their strategies are probably reasonably good they might not be optimal but they're good enough to survive but only a few innovators are needed or could even survive in a society because everybody else parasitizes them and by parasitizing those innovators the copiers actually do better they don't pay the costs of copying so we're really faced with a quite a profound realization about a social animal which is that the strongest selection acting upon our cleverness might be to be good at copying it recognizing a good outcome when we see it and acting upon that rather than being good at innovating ourselves and this might be why we're glorified karaoke singers well let me give you some some data from the real world i mean this isn't lost on businesses so you know i mean business espionage is a very big thing right it's very very difficult to come up with good ideas in industry so businesses are constantly spying on each other they're constantly making their employees sign contracts saying that if you leave this company you cannot go to another company in the same industry for x number of years where x is a number that's calculated to to kind of predict how long it will be before the technology that they know about has gone obsolete countries spy on each other for the same reason you know cyber theft um fishing around on other other countries um computers to find what they're up to to steal technology innovation is hard it's far easier to steal from those things that have worked so let me show you some data that might surprise you here here is some data from um 25 000 companies that were followed or are still being followed it's a very very long longitudinal database um uh 25 000 companies and and among many many many other things this database records why companies die why they go out of business or or vanish from the stock market and there's a whole lot of reasons there that companies die you know bankruptcy privatization liquidation and so on but look what's the top reason that companies go extinct in the sense of vanishing from the stock market they get gobbled up by other companies mergers and acquisitions so the number one reason for a company to be removed in name is it gets eaten up by another company innovation is hard it's far easier to steal somebody else's technology or knowledge and skills okay we

want to ask some difficult questions now but i hope you find them interesting we want to ask how stupid can you be how stupid can you be and what's let's define stupid as lacking in the ability to innovate or even to recognize good outcomes so so far we've allowed us to be able to recognize good outcomes and we are good at that so i'll let the cat out of the bag we are good at that we're not good at innovation we stumble along with innovation.

we're not as clever as we think but we're good at recognizing good that's why we can parasitize innovators but how stupid can you be how stupid can this species be and for that matter all other species well let's define two kinds of stupid let's define quite stupid as that you never innovate but you recognize a good outcome when you see it so innovations around you can be directed or random so all those people around you who are innovating their innovations might be directed that is they might be clever or random but so long as you can just recognize a good outcome when you see it you never have to innovate so you can be quite stupid you just have to be able to recognize a good outcome when you see it but let's define the far end of that scale let's define infinitely stupid and we're going to operationalize that is that innovations are random and copying is random so now you don't even recognize good outcomes when you see them innovations happen around you at random copying is random but we're going to assume that better outcomes accumulate in the population because there's some form of heritability or differential survival so people are innovating all over the place without realizing it some things that they produce are better than others those people survive you're just copying at random but if for some reason the better ideas even if they were produced at random have a better chance of surviving just by chance you're going to copy the better ideas so you can see that we could be very close to infinitely stupid and we could still have cumulative cultural evolution so long as better outcomes have a higher chance of surviving now i don't think we are infinitely stupid i don't think we're far off it to be honest because we don't really think of cultural evolution as being heritable in the same way as genetic evolution so if you in your in your genome you produce a mutation that makes your offspring fitter your offspring has a higher chance of survival but if you culturally just randomly produce some mutation it may not translate into a higher chance of survival for you and even if it does there's no particular reason just because you survived that anybody else will adopt that thing because remember people are copying at random and this is a this is well known in mathematics it's it's something called drift so good ideas would just drift around in the population they wouldn't be preferentially copied so if we are like that we could be very close to infinitely stupid but it seems that progress would be very very slow in that world whereas we've made quite remarkable progress so i put it to you that we're probably quite stupid not not infinitely stupid well i hope that you've been hearing some of the parallels here between cumulative biological evolution and cumulative cultural evolution because you know that biological evolution is the gradual accumulation of let's call it genes the gradual accumulation of genes and over about a billion years we've gone we being eukaryotes have gone from a single-celled organism to these wonderful multi-cellular things and natural selection natural selection acts on the best random mutation so innovations in nature are not directed they're random but natural selection preserves the best of those so just by chance you produce a good mutation it gets selected by natural selection okay so so it could natural

selection could be seen as somewhere between infinitely and quite stupid and it's done a pretty good job although rather slowly okay cumulative cultural evolution then is the gradual accumulation of ideas and what we do as a species is we subject ideas to great big tournaments of selection we can all witness all of the ideas around us and we can retain the good ones and discard the bad ones so we can all somehow participate in all of the ideas of the society that we're in okay and there's a there's just a time series of the gradual accumulation of the technologies that might have led to the steam hammer okay now we want to talk about the difficulties of selecting for intelligence i've been suggesting to you that we're somewhere between infinitely and quite stupid we want to talk about the difficulties of selecting for an intelligence in a social species to see why it is we're perhaps karaoke singers rather than that guy with a great big bulbous brain so in a world of copiers your intelligence if you're an innovator your intelligence benefits everyone so what's the point of being an innovator your intelligence benefits everyone you pay the cost of innovating but the copiers benefit from your hard work and i call this visual theft we're a species in fact i think it's pretty clear that we're the only species that's capable of this this visual theft that is we actively watch people for their innovations and we copy the better ones we can recognize good outcomes when we see them so copying is a form of visual theft.

well if you're an innovator i'm parasitizing you so what's the point in being an innovator so copying is visual theft and innovation is an act of altruism and pure altruism just has no chance of spreading in a social species so we might think here we are here's our society of of sort of dull innovators and this one person has this light bulb go on in their head but everybody can see it and they all benefit from it so within that social group innovators are going to be very very rare because if we have a lot of innovators in our group they'll just be parasitized by the copiers and they will not survive as well as the copiers how about intergroup competition maybe if two if groups were constantly competing throughout our evolution one group could could get more intelligent than the other because it's the entire group that's competing that's possible but migration between groups would always sort of negate those things and if humans of course are very very good at eavesdropping we spy on other people and we'll see in monday's lecture that that's a really important part in fact all of this is a really important part of the human tendency to form powerful and cohesive and exclusive tribal societies it'll be a lot of it will just be about protecting technology okay so that's the difficulty of selecting for intelligence in the social species and so we might want to think about this a little bit because there's some real puzzles and one of them is the puzzle that is the heritability of intelligence now heritability is just a a a a statistical measure of you you'll all have a colloquial understanding of this the higher the heritability the greater the chance is that whatever your parents are you will be that and it's a number that ranges from zero to one it's sort of the proportion of the variance accounted for and so if if heritability is one whatever your parents are you will be that so clones have a heritability of one if heritability is zero your outcome is orthogonal to whatever it was your parents had now intelligence is really rather highly heritable and i put 0.8 in there other people would disagree say it might be as low as 0.5 it's probably a bit higher than not 0.5 but it's it's high it's higher than most heritabilities in nature now you might think well that's just obvious of

course intelligence is heritable if you have smart parents you want to be smart but wait a minute wait a minute heritability means that if you have dumb parents you're going to be dumb now any population geneticist will know and this is something you should think hard about that heritability is actually a measure of how unimportant a trait is so all of you have five fingers heritability of finger number is perfect all of you have two eyes heritability of eye number perfect all of you have exactly the same number of vertebra there's no variance in those things why is there so much variance in intelligence well what happens in natural selection is that things that are really really really important that go to what's called fixation everybody has them but things that aren't so important drift around a lot so look at the heritability of intelligence in humans not point a that could suggest that intelligence hasn't played a very important role in human society or and this is what i want you to think about it could suggest that there are various kinds of intelligence that can be selected for and they come out differently along our scales that we just in a very very chauvinistic way brand as intelligence when we say intelligence we don't really know what we're talking about we just think it's things like solving crosswords and solving puzzles and being able to do a bit of maths so perhaps it's the case that natural selection has selected for copying ability that that's really one rather important component of intelligence to recognizing good outcomes perhaps natural selection has selected in us for good eye-hand coordination is this intelligence one of the things you should realize about human species is that our eye hand coordination is i think absolutely unparalleled i mean you you try to teach a chimpanzee to juggle you'll get nowhere you try to teach them to dance you'll get nowhere our eye hand coordination is extraordinary and you might think that that's because we are a species of copiers to be able to copy the person throwing their spear or chopping with something or flaking a hand axe you've got to be good at eye hand coordination all kinds of intelligence that might have been selected for sneakiness and deception humans are probably unrivaled as a species in their ability to deceive there are stories after stories after stories of people being let out of jail because they pass the parole board and they go out and they kill somebody because they've deceived the people in the in the parole office to think they're okay now so sneakiness and deception and this is to get around the problems of visual theft if somebody thinks you're stealing from them they're going to hide their their best ideas and you can imagine what would happen if we lived in a society where all of the innovations that you might have just come up with by chance alone you thought somebody was going to steal we'd all walk around like this all day not interacting with each other not sharing our best ideas okay furtiveness about your own innovations social acuity we are an extraordinarily acute acutely social species we're very good at understanding power relationships forming coalitions and those coalitions are very fluid these are all things that we might have been selected for and i think we have been very powerfully by natural selection but they're not what we would normally think of as these silly paper and pencil measures that we call in our western society intelligence okay how about particular cognitive specializations we know there are people out there who are really really good at music really really good at art mathematics etc things that are perhaps really valuable somehow to society but difficult to copy so they've been somehow let away from that problem of being parasitized so these are all issues that we need to think hard about because we value intelligence so much and yet it's probably the case that we have evolved

because of our nature as a species of being able to recognize good outcomes and produce this cumulative cultural evolution we've probably um evolved as a species to make what we call intelligence less important than we'd like to think okay think about those things let's let's move away from that now but not completely in a sense of let's have a look at these people here and i think there was some discussion of this last night there are people right now living in the amazon rainforest a stone age existence absolutely a stone age existence an existence that probably hasn't changed much in tens of thousands of years and i shouldn't say too many tens because they've probably only been there about 12 000 years those people but they will be descended you know from siberian people who came across the bering strait anyway their their their lifestyle hasn't changed much they're living right now a stone age existence these are extraordinary photos these are uncontacted tribes and if those people on the left look a little bit alarmed it's because they are that picture was taken with a really long telephoto lens but when you live in the jungle and you're surrounded by other tribes your ears are always picked up um for for things you're not expecting these people on the right this is really rather sad the brazilian government i mean they have to they fly around the amazon trying to find these uncontacted tribes and they find helicopters and the poor people on the ground come out with their bows and arrows to shoot those helicopters down and you might sort of chuckle at that but i know a fellow who actually was there at the first time one of these uncontacted tribes was um contacted and he was able to work out that when those helicopters fly over the the people on the ground think that they're giant insects you know like dragonflies and the proof that they're giant insects and they need to be killed is that they can see people inside them the the pilot and these giant insects they conclude have eaten humans.

you've got to kill these things so this is really rather sad so here are these people living in stone age existence at exactly the same time that we've got people you know could be in glasgow could be in new york could be in london living this existence now what's the difference between these two people if you gave the people on the left one of our iq tests they wouldn't do very well but i put it to you that they're probably cleverer than you are whereas these people on the right are karaoke singers there's no difference in intelligence between these two or if there is it favors the people on the left because they've got to get up every day and survive when you're a hunter-gatherer you're constantly hungry you don't have refrigerators you don't have food stores because insects and other things will eat that food predators are drawn to it so every single day you've got to find everything you're going to eat so these people on the left if anything are probably cleverer than us they live by their wits we don't have to we're karaoke singers what's the difference the difference is and it makes the point of this entire lecture is that these people have lived in a society surrounded by other ideas whereas the people on the left have been cut off from ideas their entire existence there simply aren't enough ideas in small small isolated tribal societies for them to achieve the cumulative cultural adaptation that we have achieved here by mixing and blending with ideas from all over the shop millions of people in our own society and millions of people now around the world so isolation is the cause of these people's stone age existence not that they're primitive not that they're stupid all right and we look around the world wherever we see isolated societies take places like north korea take the eastern bloc

before the iron curtain came down these places were all primitive in a sense compared to western societies and it was because they had closed themselves off from the rest of the world there was very little innovation in those societies historians this is not something i'm certainly not expert on but historians like to think of the mediterranean uh in classical times as the first internet you know so all of us know enough history to know that the phoenicians and the greeks had pretty prosperous societies you know 2000 years ago and some historians think that's because of all of the interconnectedness the flow of ideas amongst all these north african ports and mediterranean ports in those classical times and so it's been it's been labeled the first internet and that might be so the reason for their prosperity and we're all aware now that we're in a period of accelerating pace of change you know and so the question is are we getting smarter and i think you'll know the answer by now is that we're not getting smarter um and here's why we're able instead of that to achieve this pace of change i'm going to show you three maps of the world that aren't maps of the world this is not a map of the world this is a map of facebook friendship links that when you plot them by their latitude and longitude they draw a map of the world and a pretty good map of the world.

although i'd like to point out to my australian friends that most of australia is dark not a whole lot of connection going on out there but this draws so the whole world now is sharing ideas we have the whole you have a good idea somewhere on one corner of the world that idea can be copied by somebody on the other corner of the world in milliseconds if you put it up on on facebook here's another map of the world that isn't a map of the world it's a map of world airline routes so not only are we talking to each other over facebook and things we're flying everywhere and sharing all of our ideas and then something that'll be familiar to scientists is that this is a pretty bad map of the world but you can still kind of see the world there and it's known as the fourth age of scientific research that we've gone from a sort of heroic individual inventor to sort of institutional research groups to national research groups of national laboratories nations produce national laboratories to try to keep up and make good technology to now we've gone to international research groups and it in a world in which the easy low-hanging fruit solutions have been found we need to collaborate with people from all over the world to maintain innovation and that graph on the upper left there is just showing you that that the the number of multi-authored papers so papers with more than 10 25 50 100 sometimes even a thousand i think authors are all on the increase to achieve innovation if we are indeed not very clever we now have to collaborate more and more and more and this is why we've got this just this just exhausting breathtaking pace of of technological growth in our societies we haven't become smarter we just have more things to combine and recombine even if by accident and so you all know that you know here this is a little bit out of date but here are 10 technologies that barely existed just 10 years ago and they're all sort of outer space science science science fictiony sorts of things now if we were really really really smart this would just be fine all of this but in fact what i'm trying to get across to you is that innovation is so hard it's so highly competitive that we shouldn't think of it as just an easy ride we're having to scratch harder and harder and harder just to stay in the same place and in fact the fortune 500 companies are not staying in the same place these are the best companies in the world look what's

happening to them they're dying at ever faster rates and so if we have a look there um the lifespan of fortune 500 companies is getting shorter and shorter so the green line is the sort of 1995 time series and you know that gone from 500 to 250 in 15 years so half of the companies had died in 15 years whereas back in 1955 the black line it was a much shallower slope so life is getting harder it's getting harder and harder just to stay in the same place and to to make it personal i guess to great britain um here's one of our great inventors uh dyson everybody's got a dyson hoover don't they they're the best hoovers around he's just pulled the plug no pun there on his electric car division he cannot this is our one of our best innovators and inventors he cannot compete in the electric car division he's he's lost billions on that but he had the the now to recognize that he wouldn't be able to compete against these huge car companies that have decades and decades and decades and decades of cumulative knowledge and technology for making cars so the billionaire inventor said that his team could see no way of making it profitable too much competition from the big players and i supposed to hear a very personal story you're all going to think i'm i'm a sexist pig my wife just bought two hoovers she didn't buy hoover a dyson car she bought two she didn't buy them for me and it's not because she does the hoovering she's giving them his presents to other people but my point is that he does make good hoovers he just can't compete in the world of cars okay i think we'll end it there and love to take questions thank you thank you mark um we're just going to get some microphones out so that we can uh be stationed ready to take your questions just in a second perhaps i could just ask um while we're getting ready you said we're not getting smarter is it even possible that there is any selection going on amongst humans in any society in a direction of making us smarter more intelligent in any of those different respects that you talked about or is that now completely gone and all evolution is only cultural yeah no i think i think there is lots of natural selection so biological selection going on on our cognitive styles and we got to be careful about calling this intelligence because as i think you all realize intelligence is just what we operationalize it as in these paper and pencil measures we really don't have a clue what intelligence is but what we do know is that the world is changing so 100 200 500 years ago it was useful to be a big brute who could go out and kill the animals for your your your woman who was back at the hovel and you'd take that food back and she'd say yes darling that's wonderful we don't need big strong hunky guys we need people who are good at social relationships we need people who are good at at working with others we need people who can form coalitions and so these these social skills i think are really on the rise and i think it's no accident and i don't say this to to get the favors of half of the huff of the audience it's no accident that women are now starting to outperform men in so many of the traditional roles in science and academia and technology because we're selecting increasingly for or favoring it's too early for the your generation to say selected but favoring increasingly people who can get along with other people so i think there is a lot of selection going on for that okay who's got a question up there thank you thank you very much um i'm not sure if i quite heard you right where's the um there you are you seem to see suggest that altruism uh is not uh an advantage in social species but i i would beg to differ and i i would uh cite the work of mark d hauser his book moral minds was was very uh inspiring to me about how evolution selects for altruism yeah um and i think that that feeds into what you've just said in response to the first question i i think that altruism is has a highly valuable uh role to play

in heritable qualities which we i think perhaps ought to consider uh as part of of intelligence yeah no it's a re really really good question and let's hear let's try to answer it without without sort of explaining it away so if i if we define altruism as you benefiting me at a cost to you it's just not going to evolve and what mark hauser's talking about mark's just is just writing about 50 60 70 years of really really careful work in evolutionary biology is two kinds of altruism but they're not really altruism that can evolve one is if you help your children right and that's called kin selection and you so you're not purely helping your children you're advancing your own genes so the benefit to you of your altruism is that you get more offspring and that's a kind of biological imperative so that's not really altruism and so that altruism fell 50 or 60 years ago another kind of altruism that humans practice and we're probably unique in this and i'll talk more about it on monday is that we seem to be able to do things that are nice friendly this is mark's kind of moral brain we seem to do things that are nicer friendly or so on because we build reputations and those reputations then come back and bring us benefits so if i'm living in a social group and i'm the guy who's always friendly and helpful and cooperative if i get in trouble you're all going to come and rescue me if i'm living in a social group and i'm the guy who never helps out and i get in trouble it's just off you go so altruism has been sort of dethroned that the only way we can get it to evolve is to take the pure altruism out of it do you want to come back on that if i could respond just with an illustrative example from uh my experience with with architect friends um particularly engineering architects there is a there is a practice that uh a common practice not to protect uh innovations amongst uh architectural engineers in order that they uh that their innovations are shared widely that this is a very common practice and i just think that that is genuinely altruistic and contributes in in in a very substantial way to our material culture yeah you're all benefiting from the fact that you're not stealing from each other and that's that you're you're just farming monopolistic sort of anti-trust practice is what you're doing i mean it's it's a it's a it's a very lovely thing but take somebody outside of your group who steals your best ideas what you know so what i'm saying is that you you all get a reputation so somehow your group of those architects have developed this morality which says we have to behave this way and if you don't you get a bad reputation so it's a reputational thing that allows that to survive so it is wonderful and it benefits your group i don't know it may i don't know that it benefits the world because it may actually be preventing real competition amongst you and you could have come up with better solutions as far as i know i don't know that i don't want to suggest that but i want you to see that it's a reputational sort of thing and it's the sort of thing that that humans are unique in in being able to do and it's it's it's one of the reasons our social groups we'll talk more about this on monday are so powerful and formidable i think this may come up again before the end of your series so um yeah shall we move on to another question glenn over there on the left this may also be anticipating something you want to talk about on monday so if so feel free to just put it off until then but i was struck by the fact that although we were talking about cultural innovation the focus the place at which all of the real change was happening was still at the level of the individual so the way that you were talking about the mechanisms of change really still focused on a change at an individual level because we're thinking about heritable traits that can be passed down from one generation to another but i was curious as to why that's the case insofar as if there's anything that we might notice from looking at

cultural groups it seems as though we've got a diversity of abilities that when combined together enable the group to do better than they would if every individual was just functioning as an individual so yeah how do we incorporate that better together dimension of uh diversity of talents and abilities in the kind of change mechanism that you want to discuss yeah you know again really all these questions really really really good so the diversity of talents and i'm glad you brought it up because i it feeds right into that slide that very sort of speculative side i was having what kinds of intelligences can we can we select for and you know it may very well be that and you know this is a really there's not a shred of evidence for this and but there's no evidence against it either it may very well be that indeed we have been selected to be good at a variety of things some of us are are are are good at at sort of physical things some of us are good at emotional things some of us are good at at planning sorts of things and it could be that societies needed all of that kind of talent and we have been selected some of us for that we can't all be good at killing animals some of us need to be planners if we're all planners we need some people who can kill so we we we might have had ourselves stratified out in a way or diversified out is a better way of putting it in a way for tens of thousands of years so that is exactly what i was trying to get at in that slide they sort of said what kinds of intelligence can we select for now how does that make the group better well there again we'll talk a little bit more about this on monday that there again the human group has figured out a way of getting everybody to show their best solutions without them getting ripped off because if i use your best solution you'll get something in return and so we've been able to solve that problem of visual theft and i think it is one of the most profound things our species ever did because it means we can combine the ideas from many individuals into one group and we'll see on monday that that's that's that made this formidable vehicle i call it our tribal group that just juggernauted around the world you know killing everything in its path and and adapting at a cultural level to everything in its path so no right exactly on the money there's one up right at the top william behind you yeah hi thanks professor i'm really enjoying it i just got a question that's really specific about uh wait i can't see them anyway i've just got one question that's really specific about um today's lecture which is very much uh centered around technology um one of the things that i've wondered about your opinion on uh more than anything else was if we start to look at the arguments that you've put forward that says uh culturally uh our innovations are something that are going along and that's what's brought us here one of the things that i noticed in today's talk was that we're talking about sort of technology from thousands of years ago such as the axe and it's progressed now to things like iphones we both know or we all know that the moore's law sort of uh technology speed this means that it's actually computers and technology which is making new technology yeah and i wondered therefore how your arguments sort of fit in with the symondon sort of thing from the 20s where it's actually technology that is a living and breeding sort of uh species which is innovating itself and that we are just the karaoke singers on the side yeah yeah now these are lovely questions are you one of these singularity people who who thinks that technology is going to get a mind of its own and it's going to race to infinity and then we're just going to be obsolete no no no it's all our english literature no i mean it's a really good question again and and the answer is we're indeed we're seeing it happen because you know ai is getting a whole lot better at a whole lot of stuff than we are again we're not that good at things we're

pretty good at recognizing faces you saw last night that we're good at recognizing words we have this uncanny ability with words as good i hand coordination a few other things we're pretty good at but it's easy to make machines better at most of the things we do and i think this is this is behind your question so in some sense technology begins to drive technology and and i'm sure that has been going on for some time could i decide quickly out of the one last point the the the idea of technology to me when we're going back to ancient green and techno is if you're really going to talk about technology one of the first technologies that we we developed was language language is a technology yeah you know i mean so i mean with all of the cultural innovation that we're talking about is what we're actually talking about is the drive of the technology that technology of language has gone through stone flints through to iphones and that is a separate species which now develop some works on its own i'm not about the singularity i'm just saying that we're on the side of watching were you here were you here last night yeah it was yeah yeah yeah no no good because i mean that that was sort of the message last night i mean the language itself is this technology it's the conduit that carries the information of our social groups it's extraordinary our language and so that's why i put these two lectures together we've got language tonight we've learned how it is we innovate and we're going to see the explosion it caused on on monday and um you know you should all be be aware that you know that none of this is to is to say that um that that we are hopeless we individually were fairly close to hopeless but as groups we have been absolutely formidable okay thank you um there's a question halfway up on the right here paul um so you mentioned you used at the beginning of the lecture uh steve jobs and the artist whose name escapes me as examples of people who uh were very very successful not by their ability to innovate but by to by recognizing good ideas and implementing them uh or putting them together with other good ideas or implementing them in the uh constructive way um this uh this it sounds to me very this kind of uh behavior or ability is similar to so what psychologists call openness one of the big five personality traits which is heritable and normally distributed and if it's normally distributed it would suggest that at either end of the polls are disadvantageous and there's a kind of optimal point where where the mean is um so my questions are do you would you uh would you agree that uh that effect of copying is uh related to or a result of openness or is it something completely different or not related to that and if it is related to openness uh what do the the extreme ends of the normal distribution which are disadvantageous look like yeah i'm afraid i'm gonna have to disappoint you i mean i'm familiar with the with the big five but i i wouldn't be able to tell you how copying slots in on that one one of the things i do want though to say about this copying is that you're all really really really good at copying there's much less variance in your ability to copy than there is variance say in your intelligence um it's it's we're just really really good at it and and compared to other species it's just night and day but sorry i just i wouldn't know in the case of the openness well um would you be able to say it is it then possible to be uh like too too good at copying or to what to be too good at too good at copying yeah early whatever whatever made steve jobs uh effective at recognizing a good idea like that is that any way where that whatever it is that made him so good at that where if it was even greater it would be disadvantageous yeah again i'm going to have to disappoint you i i i wouldn't want to speculate we might be too good at copying if it was only it at the expense of not looking around you for other

innovations that were even better um then it might be disadvantageous yeah i think that probably relates to how you deploy how you manage your your reputation there may be a link in there somewhere okay um anyone else got a question yes down the front here please blue jumper hi thanks for your uh lovely presentation uh quick question is the creativity in copying is there creativity in copying yeah but but and so by that do you mean that when we're copying we might change things a little bit do you have to be creative to copy and innovation yourself now there will be people in this audience who was it i was having dinner with last night who will know the answer to that in fact mark i think knows the answer to that i don't know the answer to that i don't know if people who are good at copying are more creative i have a feeling the answer is no in the sense that we're just all really really good at copying when i say copying i don't mean that somebody you know does a little cartoon and you can do that that's that's artistic ability i mean recognizing good outcomes in other people and following them so if i might just to follow up on that so then why do people innovate at all well the point of the lecture is there isn't a whole lot of innovation so so what what what we we get from the thought experiment that allen rogers did was that there's always a little bit of room for innovators there's always a little bit of room now if by innovation you mean oh i don't know you tie your shoes a little bit differently from the way your parents do let's not consider that to be a huge innovation i'm sure we're all innovating a little bit you know we're not that stupid but but the the stuff that really drives cumulative cultural evolution the stuff that's really made a difference to our species it may be the case that there aren't very many of us who are contributing to that just to take that further slightly in behavioral ecology a field in biology there are optimal strategies and evolution is taking us towards those optimal strategies uh it may or may not ever get there but in those terms it's not that some people decide only to innovate or only to copy each individual organism maybe of our species we evolution may have optimized us for deciding when to copy and when to innovate and that those are there's a fixed proportion and maybe that proportion varies from individual to individual yeah so this is society to society what marx describes what's called a mixed strategy so everybody's a little bit of each the point i was trying to make though with innovation is that it's really really hard and what evolution also does is it maximizes fitness and if you can get by reasonably well with not having to devote remember last night i was telling you how expensive the brain is without having to devote brain cells to innovation if you can get by without having to to devote time and energy and and your personal well-being to innovation you'll you'll copy and um so it's it's it's an open question whether we're all a mixed strategy person we innovate one percent of the time and we copy 99 or whether some of us are copiers and some and i suspect it's it's closer to the two different kinds of people than than everybody's mix everybody's mixed in the in the small way you were suggesting but i think in the in the sense of being a real innovator yeah okay thank you i think there's a question over here danielle on far end of the road thank you it's said that left-handedness uh persists at about 10 percent of the population and i wonder whether this is a heritable or selective attribute that is related to copying because a left-handed person will always do something differently conversely well actually it's it's interesting you should ask about left-handedness um kevin leyland the guy who did that tournament many many years ago he tried to think really hard about left-handedness a lot of people have kevin happens to be one of them um turns out that left-handedness is

another example of these strategies and in a world of right-handed people left-handed people have a small advantage in some things like being a bowler and cricket okay so or fighting with a sword right so um left-handedness is probably kept at a low level for the same reason that or the same sort of argument innovation is is that in the case of left-handedness it only has an advantage to be left-handed when there's a small number of you yes the point i'm making the left-handedness are innovators because they're called no i don't think i don't know if there's there's some people who think that left-handed people are are sort of left they're not so left-brained dominant that they're more oriented i it could be a myth i don't know if this is true oh i've got a left-handed son he's very creative guy whether it's because he's left-handed i don't know okay um could we take one from over nearly opposite you there danielle on our left so we're we're all copying we're all copies of something we or what we'll all copy things we copy yeah all the time but are we not really mainly consumers of inventions and you know because copying involves some sort of activity and input a personal either mental or physical input which we don't do nowadays especially in the era of for like continuous development of automation.

yeah so how would you place them yeah so i'm not quite sure what the what the point is that well you say we are all either copies we all copy or we all innovate this is the dynamic you presented think of consumers as consuming things that they would want to copy right it's just that you can't just make everything yourself so you consume some of these things right i mean can we all consume right well mainly we're predominantly consumers yeah yeah but that sort of goes with everybody just being a copier right so you don't have to make your own clothes anymore you can just go and buy them right you don't have to be an innovator exactly well therefore we're consumers we don't actually create this these things that we consume we are so because copying involves our creative input as the gentleman was saying before you don't just yeah we're consumers yeah that's fine if you if you want to see consuming as being a creative uh enterprise that's all right i mean i think really that's a it's a different dimension entirely i think it's very where things are being taken over by machines and robots yeah okay um so are you all familiar with the phenomenon of collective ignorance i mean it's really the best demonstration of how we've been we have evolved to be followers rather than leaders so the phenomenon of collective ignorance is that now i'm sure this has happened to all of you you've been you're in a lift and it's packed full of people and the alarm goes off what do you do or you're on the tube down in london and the alarm goes off what do you do you all sit there quietly don't you looking around seeing what everybody else is doing everybody's doing that so you're all copying each other and thinking there's nothing wrong and that phenomenon of collective ignorance is seen over and over and over again it's actually quite dangerous because it means that people don't behave sometimes as they should in emergencies because we we don't want to embarrass ourselves and so we we sort of hunker down and see what everybody else is doing and we all read that off of everyone else another another nice example of um why it pasted coffee is when i was first when i first moved to britain long long time ago i i was um i had a car and i was sometimes drive across london and my my wife wasn't my wife then but she was somehow she became my wife in in spite of this we we should sometimes come in the car with me and she grew up in london she knew london really really well and i don't

know if you've ever done this you traverse london you know it's just endless roundabouts going a zillion different ways and so every roundabout we'd get to i'd say to her which way should i go because she was from london which way should i go now no one would ever accuse my wife of being a patient person so after a while she would say to me just follow everyone else i kid you not that's what she said and but i want you what i want you to think about is that it's a little bit like random copying that if you follow everyone else everyone else is probably going somewhere you know they're not going to a dead end it matters so following the majority is something that you know is really deeply ingrained in us um and i don't suggest to you that that got got us home but it it was a better answer than no answer at all put it that way there's a historian i think called neil ferguson who has posited that at certain points in human history he mentions the printing press and the rise of social media just now then immediately after those times when communication has become wider spread that it's almost inevitably followed by um social unrest political and social unrest and on your graph and following actually what you've just said about collective ignorance that if the communication of ideas kind of continues to go exponential is there not an argument that actually we need to stop thinking for a wee bit because we actually need to have time almost to come to terms with the ideas that have been posited and actually copying and a little bit of collective ignorance will do us no harm whatsoever yeah it sounds like someone who's exhausted by society i think we i think i think we all feel that don't we and um and you make you make a really nice point that i think a lot of us agree with and yet this is one of the problems of evolution is that if two-thirds of us do that or three-quarters of us do that but there's one quarter that aren't exhausted and whatever it is that society is doing has greater benefits wealth fitness you know more children somehow they're going to supplant us so um you what you're really talking about is kind of the tragedy of the commons really and you know little greta tunberg going around the world convincing us finally that climate change is happening is saying to us get off that bandwagon so i'm sure there's a lot in in what you're saying it's going to be very hard to implement though we're very evolution is very short-termist it it looks for payoffs that are immediate.

it is what you're saying that what we need is some innovators to help us manage this rather than coming up with new ideas but actually ideas on how to manage this better the the cynical the cynical view in controlling human behavior is that we don't act until things get so bad that it's worse to do nothing than to act and you know that's a very very cynical view but it's you know it's why we have taxes it's why we have penalties that's why we have jails and so on and um this climate change thing because i brought it up i have to continue with this um you know it seems like we're all realizing how bad it could be now and the the things we're being asked to do like not take plastic bags away from waitrose i mean that's just not going to get us there it's going to be much much harder than that so wait and see i mean there's nothing in the history of the human species to suggest.

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