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Science of Consciousness

Melvyn Bragg : Hello,the question of consciousness,or sense of self and how we're able to imagine things when they're not there,are problems that have engaged the great minds of philosophy for thousands of years.Consciousness has bee linked to language ,has been married to the mind and divorced from the body.It's been denied to animals , opposed to the subconscious and declared irreducible,but it still seems to defy definition,and the debate rages on as to why we evolved it at all.

Perhaps science will finally provide the answer.Today I'm joined by the Nobel prize winner,the Neuroscientist Gerald Adelmann,who claims his new book,"Consciousness:How Matter becomes Imagination" is the first ever explanation based upon scientific experiment.Also here,is Igor Alexander ,who's been studying Artificial Consciousness for more than 30 years.He's Professor of Neural Engineering Systems at Imperial College,and author of a new book also,called "How to Build a Mind",and representing the world of Philosophy,is Professor Margaret Boden,and expert in Cognitive Science,at the University of Sussex.

Gerald Adelmann your work in Neuroscience is focused on what you call "Neural Darwinism" .You've said you wanted to complete Darwin's programme,could you elaborate that for us please?

Gerald Adelmann : Well,yes,I adapted that term because I think that Darwin made the most extraordinary advance in so-called "population thinking".The idea that categories and species of animals come out of differences in populations of individuals under natural selection or competitive constraint,and my personal belief is that since **the brain doesn't appear to be a computer**,and therefore subject to the laws of logic in a fundamental way,that we have to have some other principle and I think that the principle is the same as Darwin annunciated,although the mechanisms are different, namely that in each brain,there's an enormous variety and a very very great difference in the neuronal or nerve populations,and that the way the brain works to get pattern is by selection,as Darwin suggested for species.

Melvyn Bragg : Can you give us any examples of that? Any examples of the way a particular selection takes place?

Gerald Adelmann : Sure.Erm..during development of the brain,there is a genetic component which determines the framework,there are a whole series of genes that have been discovered called Hox genes and Pax genes (sp??) that set up the initial framework for say a human brain,but in a very short time,another principle takes over,which might be stated as neurones that fire together,wire together,and that's not genetically determined,that's determined by events that occur in each animal,and that creates an enormous diversity in the connectivity of each individual brain,even the brains of identical twins.

Melvyn Bragg : But when you say,"neurones that fire together,wire together",that's going to leave some listeners behind,so could you just open that up,before I go round the table?

Gerald Adelmann : Sure,sure.Well neurones connect to other neurones by connections called "synapses",and it's well-known that during development,for example,if two neighbouring neurones in one's retina,or in that foetuses retina fire,then the connectivity of the extensions of those neurones called "axons",will be influenced by that firing in such a way as to establish them over competition.So they'll bind together in particular parts of the brain.Now that's not genetically determined,it's individually determined by the history of that animal.

Melvyn Bragg : And we're talking about billions of neurones?

Gerald Adelmann : Oh yes indeed! We're talking about for example in the cerebral cortex,which if unfolded would be the size of a large table napkin,and about as thick,we're talking about 30 billion neurones,and one million billion connections.If you counted one per second,you'd just finish counting 32 million years later.

Melvyn Bragg : I think there's a pause for thought there.Igor Alexander what's your reaction to Gerald Adelmann's drive in that direction?

Igor Alexander : Well one of er..great agreement! Certainly it's been something that's interested me for a very long time,how these populations of neurones,actually represent the world out there,and this...if they fire together,wire together,is what we'd really call "learning",the basis of learning,which is something that doesn't happen in conventional computation all that much.So this is what distinguishes the the neural networks that we have in our heads,and some of the neural networks that we can put together in the laboratory,and by following that through,quite a lot of interesting facts about consciousness can be studied on a computer,in the laboratory,and er...yeah,there's till a lot of mysteries around,we're not absolutely clear how this learning mechanism of firing together and wiring together,actually does give us a sensation of "a world out there".We're beginning to see how it would allow us to create simple patterns in the firing of our neurones,but there is something deep and mysterious that still need to be followed up,and I think it's a job for Neuroscientists and Engineers to work together on ,because there's a lot of systems science that goes into explaining these things.

Melvyn Bragg : One thing that daunts me is when I was reading about this is the number involved,I mean Gerald Adelmann gave us some idea..a synapse a second takes you 32 million years,you're still counting.What sort of control group can you get out of that? I mean how can you deal with that mass? When we're talking about Darwin and populations,he dealt with relatively few finches,as it were.You're talking about billions and billions and billions and billions more neurones than there are particles in the universe by an enormous number.How can you get a control on that, Igor?

Igor Alexander : Well perhaps not more neurones than there are particles in the universe ,but certainly....

Melvyn Bragg : More neural circuits?

Igor Alexander : ...large number of circuits....

Melvyn Bragg : More neural circuits? Yeah.

Igor Alexander : ...erm I think you must just decide,you're not going to be phased by these large numbers,because the behaviour of neurones is a bulk property.

They do interact with one another,and even if you study a much scaled down version of a neural net,you can grab hold of the principles that cause it to do anything that might be called intelligent.

So,you know,the kind of neural nets we build are about half the size of a bee's brain,and you say "Well,okay,you're nowhere with that",but it's quite interesting that half the size of a bee's brain can do some remarkable things,which are scaled down versions of what happens in human brains.so don't worry about scaling!

Melvyn Bragg : Er,Margaret Boden,d'you feel that philosophy's been left behind in the study of consciousness,by indications of what's been said by Igor Alexander and Gerald Adelmann?

Margaret Boden : Erm,no,I mean I entirely agree with Igor when he said that if we're going to understand consciousness,then the Neuroscientists and the Engineers,Systems Engineers have to work together,entirely agree with that,and I would say,and there's a third person in this trio and that's the philosopher,because again as Igor said,there are some deep mysteries here,which I don't think are purely scientific mysteries.They're partly scientific mysteries and they're partly conceptual,that is to say philosophical mysteries,so as the science....

Melvyn Bragg : For example?

Margaret Boden : Well,I mean the one he mentioned,I mean the one I think that people think of above all,how is it possible to get qualitative experience out of anything happening in the brain? Now of course we look for,and Gerry,has,for example,among other people,has found some very interesting and systematic you know,correlations between the sorts of things that happen in the brain and some of the sorts of features of conscious experience,and that's obviously very important and absolutely crucial,but I think that at the moment we are not in a position where we can say that we understand,what we mean by qualitative consciousness,well enough to say that given that these

things happen in the brain,then there must be qualitative experience,er I'm not saying that we'll never get to a point where we can say that,and we'll only get to that point,partly from scientific study,but it does involve a philosophical advance too,and I think that you know,maybe a hundred,maybe five hundred years from now,we may well have a scientific theory of consciousness,but I think it'll be in some ways, you know,very different from what we think of now.

Melvyn Bragg : What d'you think about the philosophical history here,because....I mean Plato, Descartes,but somebody you refer to very emphatically is the American philosopher William James, and his description of consciousness,so could you bring philosophy into your summary,of your position?

Gerald Adelmann : Well,of course William James,whom (indistinct),the American scholar called "that adorable genius" was not only a philosopher,but also a psychologist,one of the founders of experimental psychology,and I guess the best example of the phenomenological descriptor of consciousness,he really did a brilliant job,in his principles in psychology,and of course one can't dismiss philosophy,although I'm not sure of this,but I think it was GK Chesterton who said "I thought to go into philosophy,but cheerfulness kept breaking in",and it's clear that from the time of the Illiatic philosophers and Plato and on,that this has been a dominant subject which finally goes around the field of epistemology,the theory of knowledge,and so there is something in what Margaret says,that this fundamental personal experience,which has been described rather brilliantly as usual by Bertrand Russell,British philosopher and mathematician ,who said you know,"light comes in the eye,there's a physical process,it goes down the optic nerve,there's another physical process,it finally lands up,whereupon,all of a sudden,the whole physical train of events,seems to be accompanied by and succeeded by,this sensation,so utterly different,that metaphysicians have spent the whole of their lives thinking up weird explanations for how it could take place".**Well I have this to say about the whole subject,that of course there is something there,and something that won't be penetrated only by experiment,but I do think it's very important for people to understand that the role of science is not to recreate the world,but simply to describe it in formal terms.So for example if I have a theory of a hurricane,and I have a beautiful computer simulation of a hurricane,and it does say "98% predictiveness"-it's not a hurricane.**

So if someone asks me about my consciousness which is ineluctably tied to my body,and the workings of *my* brain and *my* history,that I should,by my theory,even if it were totally predictive, generate in some zombie the notion of what green is,there's a real category error here.
The philosopher John Locke ,the great British philosopher,once described the blind man who said "I think I understand what crimson is" and someone said "what?" and I think it was something like,"it's like the blaring of a trumpet",and so given the fact that it's tied to your body,it's clear that no scientific theory per se,can generate an exterior perception in some other creature.You can't transfer the thing,it is ineluctably tied to you history and body,and you will have those experiences.

So I don't think it's the role of science proper,to give a complete explanation of that.I think it's the philosophical and symbolic significance that has to be explored.

Margaret Boden : Well,I think that it's the role of science,and it's certainly the aim of science to explain that,it's quite different from *generating* it,I mean you're quite right,a theory doesn't generate anything,it doesn't generate the phenomenon.

But if you talk about a theory of hurricanes,then the meteorologist is able to say,"Well if this that and the other physical process happens,you know,these winds and these pressures,and so on and so forth,then you must...you must....not just you will....but you *must* get certain other phenomena,namely the hurricane",on pain of self contradiction.Right,within the explanation,and what I'm saying is that at the moment,not only do we not have this,the conscious experience,but I don't think we have any...certainly no clear ideas,maybe even not any very helpful ideas at the moment about how we might do that.I'm not saying we'll never get it.We don't have it now.

show that seeing is not a passive physical activity.Indeed those that see things that aren't there (have visions)

presumably "see" something,but it is obviously not an object that reflects light.
In some sense we create an enigma,because the mind is trying to deduce what the mind is doing. Steven Rose at the OU has alluded to this,and thus is trying to describe itself in terms of itself,and creating a paradox of the infinite.But I think there is an error being made in terms of reference we define things and look to see how those definitions can be defined in terms of the other definitions,and ultimately hope to find the first definition.The flaw is that a first definition has to be made,and without it nothing else follows.Thus the insistence of those that I have spoken with that I have at least one belief- that I exist in a reality - I think therefore I am -LB]

Gerald Adelmann : Well,this notion of "causal compulsion" that it *must* be the case is in fact something that I think scientists really avoid,even with the 2nd law of thermodynamics ,you're always probabilistic about even your causal explanation,and I would say that in fact **we *are* coming on some notion of what that involves**,for example,it's well known that if you destroy a part of the brain called the "Mesansophalic Reticular formation" (sp??) that's the end of consciousness,you're in coma steadily.

It's also in my book,described how it might be that a memory based on previous experience of category,could interact with what's coming in,in terms of perception,to give a scene.Now the quality of that scene,as you feel it,green, red and all of that,comes into this philosophical notion of *quali* or *qualia* ,and I think all conscious experience involves qualia,and what I think they are is higher order discriminations.

And we *can* tell,I think,from our theories and work,what makes the difference between one another,but the actual experience itself,I think will elude anybody,except somebody with a body!

Melvyn Bragg : Igor?

Igor Alexander : I have a little more hope for science .A couple of examples.There's a brilliant paper by Thomas Nagel ,which asks "what's it like to be a bat?",and this is the third person experience which he points very clearly to,you cannot have a scientific approach to,but what science does in very simple terms,is to work out what a bat needs to have in order to know it's a bat.

We are never going to know! But how do we know that that bat has the right circuitry to know anything? And I think that *is* a scientific question,and perhaps it's an important one.

Melvyn Bragg : But does a bat know it's a bat?

Igor Alexander : A bat knows its a bat enough to survive as a bat,and that maybe very little,in comparison to the sort of things we have to know to survive with our complexity.

suffering is a criterion to judge by.They also exhibit traits equivalent to our own,just how far down the scale we should go is looked at by Danah Zohar in "The Quantum Self" where she even checks whether rocks or electrons should be considered conscious. Perhaps the term is too limiting? There is certainly no sense in which a bat can know it's a bat,without having a dialogue with a human being to determine what "batness" is.There maybe a bat's "batness" peculiar to itself,that we have no knowledge of,but it certainly cannot think it is a "bat" as we understand it.It has no idea of the use of it to refer to madness ie "bats in the belfry" or of how "batman" has influenced our movie history,or of the association we have made with vampires.This whole thing is driving me bats! -LB]

The other point is that David Chalmers,an American philosopher I guess,a current philosopher has divided the problem into the easy problem and the hard problem.He says that anything that you can do by fiddling around with neurones,and doing experiments on brains and so on,that's the *easy* side of the problem, and he describes what Margaret was saying as the *hard* side of the problem.
Well,what happens in science is that the easy problem turns out to be enormously hard,and it requires a lot of

scientific effort,and as this scientific effort progresses,it impinges a little on the hard problem, and I suspect that at the end of all this,it's going to get rid of it altogether.

Melvyn Bragg : One of the most enigmatic qualities of consciousness,is it's ability to be unified and fragmented at the same time .I mean you are talking,Igor is talking at the same time,there's no doubt that you have 58 other thoughts,and aware that this studio is painted this colour,and you microphone is red,and all these are going on..except....but I hope,and want to go on thinking about just getting on with this conversation! But there's hundreds of other things going on.Now is it possible to explain *that* process...through the function of the brain's neural networks?

Gerald Adelmann : Well that....that is in fact a central concern of our book.The fact that consciousness has that apparently contradictory property of being unitary,in the sense that there's no way of decomposing your present awareness into this umbrella,and I think without creating yet another full scene,and James was very aware of this,and at the same time though,from within,there are billions and possibly a countably infinite number of conscious states that you can have.Think of all your class mates the pictures, the movies you go to,just what's happening in his room.How do you put it together? And we believe,my colleague and I,Julio Tononi and I that the approach to this is to have a formal analysis of complex systems,not complex computer systems.There's a full theory of that,of *algorithmic* complexity,as it's called,but of the brain as a complex system,and if you work through that,you will see that you can get integration as well as differentiation,by these mathematical analyses,I won't bore you with the details.

But it's a very general property of consciousness,that must be explained,and I think the way you have to do it,is a bit the way physicists approach thermodynamics,you have to get some measure of what it is and what it isn't?

Melvyn Bragg : Igor?

Igor Alexander : It's odd how I came to almost the same conclusion but from a completely different starting point.The starting point for me was "Why is it that almost 50,well certainly 50 years of something called 'artificial intelligence' has done enormously smart things with conventional computers, but why is it that it never got to grips with just these issues of how within our brains we can have both the integration and the diversity at the same time?".

It turns out that,the principles of operation of the brain are completely different from the principles of operation of a computer.

But working backwards,through the question "What is it that a brain-like system -never mind the real brain - but something that we would recognise as a brain-like system,needs to have in order to do just this thing,to think about a million things at the same time,and also use most of its neurones in some integrated way to do it,and some of these answers actually lie in engineering,and in control theory,and have been around for a very long time.I'm not too fond of the word "complexity",I think it kind of throws you a bit when you say this is..."it's the complexity that we need to understand". I actually think that we should get rid of that word.

Gerald Adelmann : Well in fact I think it was Ravel who said about good music,"complex m'ais pas complique" - you don't want to have it complicated.I can define a complex system I think in a crude way to get the idea across.It's a system in which the smaller parts are more or less independent and don't exchange much information,but as they get interactive with each other,more and more, information is transmitted and the thing goes from being sort of like a gas in it's small parts,to like a crystal in its large,and so yeah,there doesn't seem to be another easily used word for this,but I think we shouldn't overdo the problem of what to use.The fact is complexity is a result not a cause.

Melvyn Bragg : Where does philosophy come in on what's been said there Margaret?

Margaret Boden : Er well I don't know whether you'll call this remark a bit of philosophy,or whether you'll call it a

bit of science,I don't think there's a clear distinction between the two myself actually.

Erm,and I think that one very important concept for talking about the sort of complexity which we're talking about here,is the notion of a virtual machine.You know the notion in computer science,AI systems engineering,of a virtual machine which broadly speaking means the organised system of very,very different sorts of functions,arranged on many different hierarchical levels and interacting with each other in hopefully specifiable ways,which is what the mind is.

And that's why I said earlier,in this discussion ,that I thought we needed both the neuroscientists- I mean that's obvious,we need the neuroscientists - but also the systems engineers,I wasn't just sort of being,you know,nice to Igor! Because I think that we do need this notion of a virtual machine,to help us think about just what this functions are.

And I think that when we *do* understand qualitative experience,we will understand it as an aspect of this virtual machine,and I think we already understand certain other,originally very,very puzzling and difficult problems about consciousness,I think have been explained,and outlined in terms of this sort of concept.

Melvyn Bragg : Can I come to machines now? Igor you are involved in creating machines.You've talked about imagining a blue banana with red spots on...for instance,d'you think that the machines you're working with will ever have have the possibility of doing that?

Igor Alexander : Well they have this possibility now,and in fact they are doing it now.Some of the experiments we've been doing recently,are based very much on the ability of these virtual machines that Maggie's absolutely right about.The word "virtual" simple means that you've got something to work with which is a bit like the real thing,without hurting anybody.I can work on virtual brains,tear them to bits,and it's not going to upset anyone.Now one of the tests we have is whether they can imagine or not,but we ....imagination has a very broad set of meanings.I'll tell you the way we interpret it.It's got to be able to imagine something that it hasn't been exposed to,during some learning period,and this is usually induced by language.So if this thing's never seen a blue banana with red spots,it should be enough for the language to induce activity in the neural net that can reconstitute this internally in the system,and that's what we call imagination.

Interestingly,erm,there are systems you can put together where tweaking some of the interconnections between these re entrant parts of the system,totally stops them from imagining.So imagination does seem to be a product of some very subtle structure within both neural nets and our brains I should say.

Melvyn Bragg : Gerald Adelmann.

Gerald Adelmann : Well,I'm very stimulated by what my colleagues have said.Let me say that first of all,and I'll come to imagination in a moment,that I think what's needed to get at these complex issues is,first of all a global brain theory,and I've prompted the notion of "neural Darwinism",for that.One of the essentials of neural Darwinism is what are called these "re entrant pathways",this particular kind of thing that is not feedback,in the engineering sense,but can be engineered,massively parallel connections between brain maps,that are constantly doing some sort of higher order correlation to give you space and time together,because the brain is not governed by logic the way a computer is,but by a central clock the way a computer is.
The second thing you need I think is the kind of thing Dr Alexander's been discussing,namely you need the ability - and Margaret as well - the ability to simulate and examine in a virtual way,these things because they are enormously complex,you can't just sit in a chair and imagine them all,you have to see them worked out.

And the third thing you need is an exact kind of experiment which gives you a neural correlative of consciousness.Now we have in fact for the last 16 years at the Neurosciences Institute been building machines,or devices we like to call them,because I think a machine is really just a derivative of a computer ,it has a definite program and a symbolic end,whereas in a brain it's a bit like the lady in the EM Forster novel "How do I know what I think until I see what I say?",and it's not an effective procedure,in a very precise way,but it leads to pattern recognition.
Now these things - and we're up to DARWIN 6 -we've named them after the great man,DARWIN 6 now has eyes and ears and is mobile and is not told anything,and as Professor Alexander has done,we simulate the brain inside a computer,and it goes and it does primary and secondary conditioning just like an animal.Of course it is about as complicated as a medium size insect,and that brings us back to your comment about "How many neurones does it take?".
Now the third thing is this matter of experiment,and it was one of great delight that when we did an experiment on living human subjects,when they were perceiving two different kinds of images, horizontal blue lines and vertical red lines,alternatively through red and blue lenses,so called "binocular rivalry",and signalled when they were conscious and when they weren't,and we could measure this with a machine called a magnetometer,these minute currents in their brain.We found that when they became conscious,there was a huge increase in very specific areas of their brain,and furthermore there was evidence of this re entry,correlation amongst massive populations of neurones firing together only when they were conscious?

Melvyn Bragg : Does this....coming back to a question I asked much earlier,Margaret,the idea of philosophers sitting down,and engaging,one might use the term with pure thought,and not getting involved with devices,machines,the sort of....what we've been...Professor Alexander and Adelmann have been discussing,is that possible anymore? Has that time gone,now?

Margaret Boden : Unfortunately it hasn't,I mean there are still far too many philosophers around,and particularly let's talk about philosophers of mind,right,who don't take the trouble to find out about the Neuroscience,and who don't take the trouble to find out about the computer simulations,but who nonetheless are,in some cases,perfectly ready to dismiss them as being irrelevant.Now I mean I've got absolutely no patience with that sort of attitude.

So I mean,take Descartes,who set this problem for us in the first place.

He wouldn't have been surp...well he would have been surprised,we're all surprised.he wouldn't have been philosophically upset,by any of the discoveries which Gerry and other neuroscientists have made.He was the one who was the first one to say "every time some specific thing happens in your consciousness,then some specific thing is happening in the brain".

"I Descartes,don't know what it is,you scientists go out and find out."

Igor Alexander : I actually think that Descartes would have had me burnt at the stake,quite honestly,because part of his talk about mind was,one that goes all the way back to Aristotle,and that is that there is something "divine" about mind that it is divinely entrusted to us,so that we can not only recognise our own existence,but also recognise the existence of God,and going back to Aristotle,**the fact that "soul" is the thing that does thinking,and "soul" is only to do with human beings,is still around when we talk about machines,and even the person driving a car while they're listening to this programme,will think "Oh well yes,but there's something special about my mind,something perhaps divine,that all this talk about machines doesn't have anything to do with."**

Melvyn Bragg : You.....sorry....please say what you want to say,because I've got a question to ask you.

Gerald Adelmann : There *is* something special about that driver's mind,it's unique to his history and unique to the

history of the universe.He has...if you come at the numbers the way we did before,you can see that clearly,that you call that a "soul" is another issue.Descartes of course was interesting,and I think wrong,but wrong the way great geniuses are,by prompting the question and clarifying it,and saying there were two kinds of things,extended things and things of thought,race extensa and race cogitans (sp??),and the first were accessible to physics,and the other was not,in a direct way.But that polarised our thinking,and that's why he's sort of the greatest modern philosopher and why what Margaret says is going to turn out to be true,and I think it will disprove his assumption.That doesn't mean that by asking the right question,even if you have the wrong answer,that you haven't done something marvellous.That's what he's done.
Excuse me,you were going to ask me a question?

Melvyn Bragg : I was going...no...I was going to say,you write in your book,"the workings of the brain more closely resemble the living ecology of a jungle,than they do the activities of a computer or any machine we could possibly imagine".

Gerald Adelmann : Yes.

Melvyn Bragg : Now could.....? I'd like all three of you to address that,d'you want to kick off?

Gerald Adelmann : Yeah,I can unpack that one a little bit.

Melvyn Bragg : Right.

Gerald Adelmann : Er let's start with the computer,after all,it was in this country that Alan Turing gave the theorem,the general theorem that describes that .
A computer involves algorithms or effective procedures,which are quite precisely described in this case in binary arithmetic,it doesn't have to be that way.But if you don't have a precise description,if there's a lot of ambiguity,you've got a problem,you've got to put in an error correcting code ,logic simply doesn't tolerate... even fancy logics don't tolerate that kind of smear.Well,the brain as I said before when I was describing neural Darwinism,is unique in each case,not only in its structure but also in its history,and we mustn't forget that it's in a body,*your* body constituted a certain way within your species etc,and the two interact in ways that can't be completely isolated from each other.Well when you put that all together,and you look at the metaphor of an evolutionary garden or a jungle,you see it has structure,but it also has uniqueness,and that uniqueness comes from variation,just as Darwin observed in finches,and whatever,and that variation,of course sometimes is trivial,and sometimes is absolutely essential.I think the main point is that one is capable in such a system of getting pattern recognition,and I personally believe that the way this will eventuate,to back up what Margaret said,is that ultimately we will do a synthesis.The way we'll really understand it is we will synthesise some structure,which actually has these properties.Now there's an ethical problem there,but I don't think one has to worry too much because it'll be much harder to make something that's like a human body.We will embody the principles of consciousness in something, some day,and therefore synthetically understand this deep thing.That will take some time but I fervently believe that just as has happened in other matters,science will finally create a conscious entity.

Melvyn Bragg : Can I come to you Igor and then Margaret? I know you're both busting to get get in,but Igor Alexander?

Igor Alexander : These virtual systems we are talking about that have some sort of virtual mind ,and possibly work on virtual worlds,all of that happens inside the computer.The computer is just a red herring as far as all that's concerned.It's just a substrate on which these complex systems run.but,one of the problems with these things is that sometimes we don't know how to design them.It's not the easiest thing for a designer of brains to sit down and say ,"I'll design this thing so it has consciousness".**One of the features of some of these things is that they have come into being through a process of evolution,artificial evolution at that,but we've had to use the concepts of evolution,and <u>emergence</u> of activities from evolved systems,which is not part of the programmers remit.**

Melvyn Bragg : Margaret?

Margaret Boden : Yes well that's part of what I was going to say.I think Gerry made a false antithesis

there,between computers and brains.I mean of course brains,human brains in particular ,are wonderfully,you know,deliriously unique and complex and so forth,because of not only there different genetic endowment,but their different life experience,of course.But if you have a you know a halfway interesting computer program,and run it...that can take in information from the outside world,etc etc,and you run it in....you give it so-called "life histories",you will end up with systems that are interestingly different.I am not suggesting they are going to be as complex as human beings of course not.

But they will be unique,and as Igor said,you can do this by using evolutionary principles in the program .I think that Gerry, when he has described in this conversation,has described very old-fashioned limited approach to computation,which isn't actually what's being done in a lot of work that's going on now.So I just think this is a false antithesis.

Gerald Adelmann : Well,I'll have to respond to that won't I? (laughs)

Melvyn Bragg : I hope so!

Gerald Adelmann : I think old-fashioned or not,Turing's theorem applies to everything we call a computer today,and that means there's logic in it,and that it *has* to be precise,and the funny thing about brains - and of course you know Professor Alexander,that I'm all for selectionistic ideas - I think what's interesting about brains is that they can pattern recognise *in the face* of ambiguity,and that computers can't,that's not a false antithesis,I'll lay down a challenge,the fact is that the power,for example,of our language is not in its clarity,but in its ambiguity.
If I ask Margaret if she were born simply,with say first order predicate logic,and algebra,would she imagine a Wallace Stevens poem?

Margaret Boden : Certainly not,but then the sorts of programs that I've been talking about that are actually... or the sorts of systems that are being built today,never mind what's going to be built in 50 years time,don't work with predicate logic and algebra,that is my point.

Gerald Adelmann : But they don't work with poetic metaphor either...

Margaret Boden : No,but they work...

Gerald Adelmann : ...and they don't create axioms,only theorems.

Margaret Boden : well...they work with ambiguity,they work with certain sorts of ambiguity,even you know,very simple neural network pattern recognisers,can you know...have capacities to recognise what you called "smearing",you know,between different examples of a pattern,which the old-fashioned sorts of systems couldn't do.

Gerald Adelmann : But they are ludicrously simple,let me.....

Margaret Boden : Oh indeed.

Gerald Adelmann : ....ask you this question.

Margaret Boden : Yes,that's true.

Gerald Adelmann : Let me ask you this question,Margaret.If I were to offer you...if you were to go hunting for birds in a swamp,a bit the way early Darwin was when his father said he wouldn't amount to anything,because all he did is hunt.Supposing you were to go for birds in a swamp on a rainy day,and I offered you the American Air Force computer in a teacup and it was friendly,and spoke English,would you take that or would you take a dog?

Margaret Boden : I'd take a dog....

Gerald Adelmann : Why?

Margaret Boden : ....because I know enough about this stuff to know that we haven't achieved very much yet.

Gerald Adelmann : Yeah.

Margaret Boden : But that's not to say that we haven't achieved more than what you're suggesting we have achieved.

Gerald Adelmann : Well I don't think we have achieved very much,but it's very important to keep the distinction.

Melvyn Bragg : Can I just bring in a - it might seem clumpingly obvious - but people listening to this programme,could say something like,"It's all very well to talk about this that and the other...but will machines ever be able to have freewill for instance?",Igor?

Igor Alexander : The answer is "never",I think there is a deep confusion that takes place between our using words like "freewill" which have to do with human beings and applying them to machines.If you apply them to machines,I'm sure you can find a machine where you could find a method...a behaviour that you could describe as "freewill".

Just proving that it can make arbitrary decisions for example.But I think that the way that the machine arrives at those things will be as a result of being a machine,whereas a human being arrives at its freewill by being a biological human being.There's a lot in common between the two ,but the confusions leads you to believe that if the machine has enough of these things,it'll suddenly become a human being.It'll cross the line.**I think that's got to be made very,very clear - it can't do that.**

Gerald Adelmann : And the reason is clear,it will not have what we call "the phenotype" of a human being.The human body is just as miraculous and maybe more so if you include the brain,as any notion of the workings of the brain,and it's absolutely essential to the brain,that you have the form and shape of your body from cells,all the way on up.So my comment would be that,I don't like the use of the word "machine" even for the kinds of things you and I work on,I'll call them "devices" for the moment,because I think a Turing machine does encompass all known machines.

Be that as it may,it would never occur to a machine I think,to imagine or wonder whether a human being were a machine or not!

Melvyn Bragg : What's your comment on this freewill .....?

Margaret Boden : Well,I disagree with both of those.I don't think freewill is a matter in general of making arbitrary choices,though we can sometimes make arbitrary choices if we choose.

I think it's a matter of a certain sort of functional organisation,a certain sort of virtual machine,you know,that we have and that dogs clearly don't,and that new born babies clearly don't.

And I see absolutely no reason whatsoever,why that shouldn't be a feature also of some hugely complex computer system.

computers are silicon circuits programmed by humans or by their senses which still has to have a program to tell it what to do when a sense occurs -LB]

Igor Alexander : It seems to me you and I are going to swap jobs at the end of this discussion! (laughter)
I was using the example of making arbitrary decisions,because one could point at a machine like that and say "Look it's got freewill",whereas what it's doing is something simple.

I think the freedom of will has got to be interpreted in the sense of the freedom of being a human being,in which case it's irrelevant to a machine.

Margaret Boden : Why people are interested in freewill of human beings is because it's linked with moral responsibility,and in the sort of choices which involve moral responsibility,they're not made arbitrarily,or if they are,we regard this as a very bad way of making them.I mean they are made with consec.....deliberation,thought,comparison between different sorts of consequences,and different sorts of moral principle.Etc etc etc.

Now what that's....what I'm...this "etc etc etc" is what I meant by talking about a very ....a complex set of functions in this virtual machine,and it isn't a matter of arbitrary choice.It's something much more structured than that,and that's what freedom is,and that's why we value it,and I don't see any reason in principle,as I said,why one couldn't have that sort of functional structure in a none human system.

Gerald Adelmann : It seems to me that it's hard to imagine...if you didn't have something like language,and thus what I call "higher order consciousness",the consciousness of a "self" and the consciousness of a past and a future,

and the ability to imagine situations of responsibility and value,and all of that in our case,I think comes from language,or at least symbolic capability that most animals don't seem to show signs of.

Unless you have that,the issue doesn't even emerge.So until you have a machine of a kind that would master the problem of language and meaning,at least symbolic formation,then I think the issue is moot.We can get at issues of primary consciousness,before we address that sticking point.Science must be modest.I believe that the issue is this: if we start with higher order consciousness,and the kinds of things Margaret says,I don't think we going to get very far.

Because it's going to be a long way before we master the problems of how language is generated and how discursive symbolism occurs in human beings,or musical or artistic symbolism,or even mathematical symbolism.

,even if it was programmed with the entire history of the problem,because it would have to create new and novel approaches.I can only just see a genetic algorithm doing this.It might also require "insight" or "leaps of imagination" or "intuition" all those qualities associated with "genius" or "inspiration",these things seem to be the prerogative of a brain that "collapses a wave function".No algorithm could attain these things *in principle*,that is the wall Marg refuses to see.Only a quantum computer could do it -LB]

But we can attack this problem of primary consciousness which I believe it's possible to recognise even in animals like dogs and what have you,who have homologous structures.So you know,one step at a time.So this notion of leaping forward to the machine that has all these implicit things,as well as freewill,because it can write a line of Shakespeare and if you challenge it,it'll write a line of Coleridge, is perhaps asking an awful lot,we don't have to go that fast.

Melvyn Bragg : Igor?

Igor Alexander : I'm not sure the demarcation between primary and higher order consciousness is as clear as is

implied.

Gerald Adelmann : Clear? Sharp.Sharp you mean,rather than clear.

Igor Alexander : I think that the artificial will knock on the door of higher order consciousness.It can't get all the way,because going all the way does mean,having the consciousness of that particular species,which is related to the survival values of that particular individual,which for a machine must be different.Even a virtual machine must be different.

Gerald Adelmann : I agree.I agree with that.

Melvyn Bragg : Margaret do you have a final comment on that?

Margaret Boden : I would just say that I think the really interesting question,both from the philosophical and scientific point of view,is "what are human beings like?",and what is human...if we're talking about freedom,or consciousness,you know what is human,freedom and consciousness like? And I don't really care whether or not one could make a machine which had the same sort of consciousness,or the same sort of freedom.My interest is how we could use that sort of study along with neuroscience to understand ourselves better.

Melvyn Bragg : Final word from Igor Alexander.

Igor Alexander : That seems to me the ultimate aim of building any machine.We don't want to build machines that are going to go round and do "Terminator 7",we want machines that tell us about ourselves.

Gerald Adelmann : And a philosophy that tells us about ourselves, something that needs to be repaired a bit.

Melvyn Bragg : Well,thank you very much to Professor Margaret Boden,to Igor Alexander whose new book is called "How to Build a Mind",and to Gerald Adelmann whose new book is called "Consciousness: How Matter becomes Imagination".Thanks for listening,we'll be back in September.