THE LEAKEY FOUNDATION

Origin Stories Being Human Episode 10: Alison Gopnik

Meredith Johnson
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This is Origin Stories, the Leakey Foundation podcast. I'm Meredith Johnson.

This episode is the second in our series of live talks. It was recorded in San Francisco as part of the Leakey Foundations Being Human event series. Our speaker is Allison Gopnik. Dr. Gopnik is professor of psychology at the University of California at Berkeley. Her research focuses on how babies and young children learn about the world. She's the author of over one hundred journal articles and several books including the "Scientist in the Crib" and "The Philosophical Baby." Her new book, "The Gardener and the Carpenter" about what the signs of child development tells us about the relationship between parents and children, is coming out in August of 2016. Here's Allison Gopnik live on stage at Public Works in San Francisco.

Allison Gopnik
What I'm going to do is talk a little bit about work that I and other developmental psychologists have been doing over many years, looking at how babies think. What's going on in children's minds and even more importantly how can understanding what babies and children are like tell us something about what we are like human beings and in particular how we evolved to be the kind of creatures that we are. I started out my career as a philosopher and my book is called "The Philosophical Baby" the book that's already out and for many, many years philosophers kind of ignored babies and children. The 1967 Encyclopedia of Philosophy had three references to children, babies, mothers, fathers; you could read back that two thousand pages of deep Western philosophical thought and think that human beings reproduced by asexual cloning.

There was no sign of babies or children in there at all, but there are a lot of deep, interesting questions that we could ask about our children. And here's one of the very— this is actually something that I'm writing about in the new book which is going to be out in August about relationships between parents and children and how those relationships evolved. So here is a very fundamental foundational question why do we have babies at all? Okay. Most of you in this audience have probably figured out one explanation for that, but that's sort of the proximal explanation, but from an evolutionary perspective why is it that we human beings have this extended period of immaturity? What is it? After all babies are at least on the surface, useless. They don't bring home the bacon, they don't do anything and they're arguably worse than useless because we have to put so much time and energy into taking care of them and our human babies are useless for much longer than the babies of any other species. My son is twenty-seven and at least until they're twenty-seven we're still writing tuition and rent checks, but even in forager societies, even in the sort of society in which human beings evolved, if you look at chimpanzee babies for example, chimpanzee babies are producing as much food as they're consuming when they're five years old. In forager, hunter-gatherer cultures children aren't doing that until they're fifteen. So that's a really long time with a really big cost to the community.

So there's this incredible puzzle. Why would that be? Why would we have such a long extended period of helpless immaturity? And it turns out that if you look at many other animals beyond human beings, you see this same relationship. So there seems to be this very general evolutionary relationship such that the longer the immaturity, the smarter, more flexible the adult animal is. And the first context in which biologists looked at this had nothing to do with human beings or even primates or mammals at all. It was looking at birds. So over here for example, that is a New Caledonian crow and crows, and corvids and ravens and rooks in general are incredibly smart birds. As smart in many ways as chimpanzees and primates. They can do things like use tools for example. And that particular kind of crow, New Caledonian crow lives on a small island off of New Zealand, is exceptionally intelligent.

So this is an animal that learned how to turn those little wires into hooks. On the other hand our friend the domestic chicken, with apologies to any chicken lovers in the audience, which in the Bay Area might be quite a few people, are basically as dumb as stumps. So they're very good at pecking for grain. They're not much good at doing anything else aside from pecking for grain and the baby chicks are mature within a couple of weeks, a couple of months. The crows are fledglings for as long as a year and these New Caledonian crows are fledglings for two years, which is a very long time in the life of a bird. We don't just see this pattern across birds; you see it across mammals, you see it very dramatically in the case of human beings. Why would this be? Why would you see this correlation?

Well, if you actually look at the crows you might actually get a hint. So, in the wild the crows use these amazing tool-using abilities to design digging tools. So what they do is take a palm leaf, called a *Pandanus palm*, they'll strip off the leaves until there are these little sharp barbs that are left. They'll nibble the end of it to a point and then they stick in a hole full of termites.

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They stir the termites around and then they pull out the tool with a delicious termite shish kebab that they invented. This is an incredible, amazing thing for them to do. If you watch the babies in that first two years of life what is it that they're doing? What they're doing is they're screwing this up. They're taking the palm leaf and they're putting the barbs on the top instead of on the bottom and they're putting in the thick end instead of the thin end. They're trying to figure out how to use this tool, but as we all know, the way you learn is through failure. The way you learn is through trying things, finding out that you're wrong and adjusting. And of course, in the meantime the mommy crows are sort of sitting there their tapping their feet wondering when the rent checks are going to stop and feeding the kids termites.

So they're essentially doing the same thing as paying tuition, but it takes the form of letting them have the sticks and feeding them the termites in the meantime. So what that suggests is that the purpose of that long childhood is precisely to learn. So that's what babies are for. Babies are for learning. That's what babies are all about and of course if you think about us human beings we are by far the most flexible, the most intelligent, the animal that relies most on learning of any species that you can imagine. And it seems as if there is this kind of evolutionary tradeoff where some animals like the chicken are beautifully suited to one particular evolutionary niche, not very good at anything outside of that. Other creatures like the crows and dramatically like human beings aren't very good at doing one thing in particular but we're very good at learning how to deal with many, many, many new environments. And we know that in our evolutionary history, one of the things we did was move. We went to new environments and even more importantly we created new environments.

So childhood seems to be a way of learning about a new place. That's what it seems to be for, but being able to do it in a protected context when you don't actually have to act. If that story I've been telling is true you might expect other kinds of adaptations that were part story and this is one of the kind of core of the new book, the book about parents and children. So if you look for example at different species of marsupials you see this same relationship between the size of the brain and the period of immaturity, but as you might expect, this trick of long period of protected maturity in which you can learn depends on having other creatures who were taking care of you during the time when you're learning. So if you have a mastodon charging at you, you don't want to be sitting there and saying, "What should I do with this mastodon? Maybe a stick? Maybe a stone? Who knows?" You want to have done all of that learning in the first place.

If you look for instance at the quokka, what you see is these two animals are about the same size. That's the world's most adorable animal that also lives off of Australia, that's the Virginia opossum, a marsupial that lives in America and the quokka brains are twice as big as the opossum brains and the quokkas put twice as much investment in their babies. The babies stay in the mother's pouches for more than twice as long as the opossum babies do, the quokkas have one baby at a time, the opossums have lots of babies at a time. And perhaps, most importantly the quokka fathers— that a father there— are as engaged in childcare as the quokka mothers are. Now, I think for human mothers, probably you have felt a little more like the opossum in that picture than like the happy little happy quokka family, but in fact, we're even further again on that dimension than the quokkas are. So in the course of our evolution, we developed in really striking contrast to our closest primate relatives, we just developed what I think of as the care triple threat. So unlike our closest primate relatives we pair bond, so that we actually have fathers who are engaged in care as well as mothers and we have attachments, bonds between the people who take care of babies, both fathers and mothers. Unlike our closest primate relatives, we do what Sarah Hrdy, the great anthropologist calls alloparenting.

We actually have non-kin parents who are non-kin animals, adults who are taking care of other people's babies. In fact a beautiful recent study of the Hadza foragers showed that babies in these cultures are actually breast-fed by lots of different mothers. So a baby can expect to be breast-fed by five or six different women in the village beyond just their own mother. And we have my personal favorite adaptation, really unique to human beings— killer whales are the only other species we know of that does this— which is that we have grandmothers. So we are the only species where females actually live on past their fertility. So chimps even when they're very well taken care of, when they get to be about fifty they stop being fertile, they die. Human beings even in forager societies women live for twenty years past their fertility and Kristin Hawkes has argued and I think quite clearly demonstrated that that's an adaptation that lets us have still more investment and care for babies.

So this combination of long period of immaturity, large brain and big parental investment really seems to be a very distinctive part of our evolutionary history. Something that happened. All these are big changes, big differences between us and other creatures and they all seem to have developed at the same time. In fact, there's even some evidence that this happened in the course of hominid evolution. So if you compare, for instance you can use dental records to compare how quickly Neanderthals matured versus Homo sapiens maturing. You can actually look at fossil teeth and find out when those grown up teeth showed up. You can see that the period of immaturity gradually increased all through the period of hominid evolution. So even compared to Neanderthals our babies are immature for longer.

All right, a way of thinking about childhood, is you could think of it as being reflecting current evolutionary division of labor. So you could think about babies and children as being like the research and development division of the human species. They are the ones who don't have to do anything except to go around and learn. That's what they're there for. Learning, innovating, doing new things. And we're production and marketing. So what we have to do is take care of those babies while we're actually engaged in the famous four F's of evolutionary success;

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fleeing, fighting, feeding, and reproducing. Babies don't have to do any of those things. Babies and young children just have to learn. If this story is true, then you might expect to see it in neural development as well and in fact, that's exactly what you do see. So this is a chart that shows the development of synapses, neural connections over time, over the course of development and what you can see is that all across the brain, there's this early period where there's this tremendous proliferation of new connections and then there's a later period when the connections that are used get stronger and stronger and used more and more. The connections that aren't used get pruned. They get cut out. So you have an early period where you have this incredibly active, as neuroscientists say, plastic brain. A brain that's incredibly well designed for learning. Very badly designed for things like putting on your clothes in the morning and getting out to preschool. Then you have this later brain that's this lean, mean, efficient machine. Very good at doing things effectively and quickly, very bad at learning something new or creating or imagining or making new connections. Not completely incapable of doing it, but not nearly as good as that baby brain.

In computer science, in machine learning for example, there's this idea of a trade-off between what computer scientists talk about as exploration strategies versus exploitation strategies. The idea is that you can either explore, think of lots of possibilities, consider lots of options when you're trying to solve a problem or you can exploit. You can try and get to the quickest kind of reasonable solution that's going to be good enough for government work and there's an intrinsic trade-off between those two strategies. You spend too much of your time exploring, you're never going to actually solve the problem or you won't solve the problem before the mastodon actually comes and turns you into prey. But if all you ever do is exploit, all you ever do is try to just get the best solution at that particular moment, then there might be great solutions out there far away From where you're thinking now and you're never going to find out about them. And finding out those weird, strange solutions far-off in the space, that's the thing that human beings are better at than anybody else, and we have some recent evidence that suggests that young human beings— babies and young children are even better at it than adult human beings.

Now, if this whole picture is true, you might expect, if babies and young children are designed for learning and they have these brains that are designed for learning— oh, let me mention one more statistic that I learned recently which is one of my favorite recent statistics— you know how your brain as an adult, even when you're resting, uses up about twenty percent of your calories. So it's an expensive gadget, expensive, energy-hogging gadget. Well it turns out that for four year olds, their brains are using sixty-six percent of their calories. Four year olds are basically these giant— they're like something out of Dr. Who— they're these giant, hungry brains attached to these little tiny bodies that are just using up all the food around them to learn and also turning us into their slaves at the same time.

Okay, so if that story is true you'd expect to actually see some of these really powerful learning mechanisms in operation in babies and children and that's where my science comes in. That's the research that I and my colleagues have done— trying to figure out what kind of learning mechanisms are these children actually using. What we've discovered is that they learn in many of the same ways that the smartest scientists learn. My first book was actually called "The Scientist in the Crib." How do scientists learn? Scientists learn by taking data and analyzing it statistically and they learn by doing experiments. And what we've discovered and I'll give you some examples of this, is that even very, very small children are doing the same thing.

Now you might ask— any of you who have ever taken a statistics course or let alone taught one will know that even grown-ups have a lot of trouble dealing with statistics a lot of the time. So what could I possibly mean when I'm saying that babies and two year olds are understanding statistics? Well it turns out that part of the reason why we've discovered so much in the last few years about how children learn, we've really completely revolutionized our picture about babies and young children is because we had to figure out how to ask the question in their language instead of our language. So one way we do that when we want to know about statistics is instead of doing foolish things like asking the four year olds "Do you think that if you have a conditional probability of .4 that's supportive of a causal relationship or not?" What we do is we actually show them patterns of evidence, patterns of data with this little device the blicket detector. It was in use today or I would have brought one. It's a little box that plays music when you put some things on it, namely blickets, and not other things and with this very simple device we can get children to show us the kinds of statistical inferences that they're capable of making.

Let me give you an example of this. This is a study that just came out. We did this with twenty-four month olds. So what happens is, the twenty-four month olds see our little blicket detector and off to one side is a marble dispenser. That MD is actually a treat and train that we used to use to train animals, but we adopted it to dispense marbles. The kids see that you put the red block on the machine six times. Four times it works, two times it doesn't. You put the blue block on, it works four times, but doesn't work eight times and then they simply have a choice of which block they want to use to make the machine go. Now both blocks activate the machine four times, but if you were doing the math and you wanted to figure out what's the statistical likelihood that the block will make the machine go, the red block is actually a better probabilistic bet than the blue block.

So if you were doing the statistics you'd say use the red block instead of the blue block. Obviously we counterbalance the blocks, but here's a twenty-four month old and that's quite typical. So what we discovered was that the twenty-four month olds would choose the block that had the greater probability of activating the machine rather than the one that had the lower probability. And in lots of other experiments that we and others have done, we've shown that babies as young as seven months old are making some of these kind of statistical conclusions. In fact, in some context as I said the three year olds actually seem to be better at doing this than the adults. So this is when we get a little audience participation which I'm told was one of the features of this series. Here's a blicket detector experiment. You can all be subjects. You see one block, block D goes on the detector three times, nothing happens. E goes on, nothing happens. D and F together go on twice and the detector lights up. Now, here's the question; is D a blicket? Don't know or no. I'm seeing more no's. Is E a blicket? Is F a blicket? Okay, so this audience is as smart as Berkeley undergraduates, but not as smart as four year olds. Because what if you also saw this sequence of events; so now you see A, B and C go on the detector independently, nothing happens. A and B go on, nothing happens, B and C, nothing happens, but A and C together make the machine go. All right? Now, if you saw that you might think, "Oh wait a minute, I was thinking that individual blocks had the power to make machine go or not, but this is telling me that you actually need combinations of blocks." It's actually the logical and combination that's making the machine go, not the individual features of the blocks. That's a much less obvious, less likely hypothesis to have about the blocks. But if you saw that and then you went back to that original sequence that I showed you, you might change your mind.

Now you might say, "Oh, maybe D is a blicket." It would kind of make sense because if this machine works on that combination principle, then the story would be that this data is really telling you that D and F are both blickets. And E you're still not sure about. So what we did was, we showed four year olds and Berkeley undergraduates exactly the sequence of events that I just showed you and either we gave them data that showed that the machine worked on the obvious order principal, either it makes it go or not, or else we showed them data that shows that it goes on the much less obvious combination principal, and then we gave them the same ambiguous sequence that I showed you. And what we discovered— I'll show you a child in this experiment — So here's what we discovered, when we did this with the Berkeley undergraduates, they always chose the obvious solution. They always said that D was not a blicket.

Female Speaker 1
Look at that! The machine did not turn on. Let's see what happens when we put the triangle on the machine again, okay? Look, the machine did not turn on. Now, let's see what happens when we put the triangle on the machine one more time, okay? Let's see. Look, the machine did not turn on. Now let's see what happens when we put square on the machine, okay? Look at that! The machine did not turn on. Okay, now let's see what happens when we put triangle and ball on the machine together. Look at that! The machine turned on! Now let's see what happens when we put triangle, square and ball all on the machine together. Are you ready? Let's see. Look at that! The machine turned on! Okay, now let's see what happens when we put triangle and ball on the machine together. Let's see. Look! The machine turned on! So, Scarlet, do you think that triangle is a blicket or not a blicket? A blicket. And do you think that square is a blicket or not a

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blicket? No. And do you think that ball is a blicket or not a blicket? Yes. Okay, so Scarlet, which of these should we use to make my machine turn on? Those two?

Alison Gopnik

Okay, so you can see the reason for showing this is partly because as a developmental psychologist, we have a moral obligation to show cute kid videos. But also, if you, as you are watching that sequence were quietly thinking to yourself, “What the f***?” You are not alone. It’s really hard to keep track of which was it? Was it the square the circle or whatever, but the four year olds were keeping track and the four year olds got the right answer. So if you showed the four year olds that it was individual objects that made the machine go, they chose just one. If you showed them the combination roles, they would choose the right combination of justice in this experiment. You do the same thing with Berkeley undergraduates, they go with the obvious solution and they always go with the obvious solution. They never get to the unlikely, unusual, strange solution.

So what that suggests is that the four year olds, and we found this pattern across a number of other experiments, the grown-ups are better than the four year olds at learning something that's obvious, that they already know that’s the most likely solution. The four year olds are consistently better than the grown-ups when it comes to learning something that’s out-of-the-box and unusual and strange and that feeds back to that evolutionary story I was telling you about why we have children all. The thought is that children are there and have this long protected period exactly to give them a space to explore weird, strange options without having to worry about the immediate consequences.

Okay, so I said that children are amazing statistical learners. They’re also amazing experimenters except that when they do experiments we call it getting into everything. Let me give you an example from another blicket detector study. This is a study that Cristine Legare at Texas did. She showed the children that red ones make it go and yellow ones don’t and then she showed them an anomaly; a red one that didn’t work. And she said to the kids, “Why did that happen?” and she gave them the box to play with. Now if you had any doubt that children are little scientists, that facial expression confirms it for anyone. This is his suggestion.

Female Speaker 2

What should we do now?

Child Speaker 1

Oh, because the light goes only to here, not here. Oh, the bottom of this box has electricity in here, but this doesn’t have electricity. It’s lighting up! So you need to put four. You need to put four on this one to make it light up and two on this one to make it light up.

Alison Gopnik
Okay, so that's a super adorable, articulate little boy, but it turns out that he was actually typical of the children that Cristine tested. So especially if you showed the children something that was an anomaly, that didn't make sense and then ask them to explain it, you saw this pattern of experimentation in their spontaneous play and one of the things that you can notice here is he goes through, I think it's eight different hypotheses in the course of this three minutes, and just like the children in the blicket experiment, they're all over the shop. One minute it's about the number, one minute's about the location. They're again, exploring the space in this incredibly wide way that it seems unlikely that adults would be able to match and he's just doing that in the course of playing around with these blocks and this machine.

Now that was a four year old. A beautiful, recent study that just came out in science actually showed the same thing, now with eleven month old babies. So what they did with these babies, this is a work by Lisa Feigenson at Johns Hopkins, they showed the babies sequences of events that were either consistent with what you'd normally predict, or were weird, were anomalies. So either the car fell off the end of the block or it kind of floated in space. Either it stopped when it came to the wall or it looked as if it went right through the wall and dissolved through the wall and came into the other spot. So they either saw things that made sense or went against what they would normally predict. And then what they did was just looked at how the baby played with the toys when you gave him the toys afterwards. Well one thing was the babies looked much longer at the unexpected case. They learned more about the unexpected case, but most interestingly, when they saw the toy apparently floating on air, then when they got the toy themselves, they kept dropping the toy.

So they would let go of it as if to say, "Okay wait a minute, it floated in the air before. Is it going to do it now?" Whereas when it looked as if the toy had gone right through the wall, they banged the toy against the top of the table as if they were saying. "Okay, now wait a minute. Is this one going to actually have this amazing disappearing power of dissolving through the table or not?" So even eleven month olds, in their spontaneous playing around with objects were actually testing hypotheses about how the objects would behave. It's interesting that they, unlike adults, were most interested and most involved when their original expectations were violated. These babies seemed to have sort of the opposite of a confirmation bias. They're really, really good scientists. I think I'll skip this in the interest of time.

Now how does our— you see these amazing abilities on the part of the children, how does adult education play into this? How does adult teaching influence this kind of creative experimentation? Well, to test this, Elizabeth Bonawitz who was a post-doc in my lab, did an experiment where she showed children this toy that has four interesting things it can do. It has a squeaker that squeaks, it has a light that shows off, it has a mirror, and it has a little piece that plays music and what they did was simply give the children these toys to play with. Now here's the video.

Female Speaker 2
Hi Scarlett. My name is Sydney. Hi. The museum gave me this really weird toy. It's so weird! I've never seen this before! Oops! Did you hear that? Did you see that? Weird!

Alison Gopnik
Okay, so she has no idea about the toy. She bumps into it, it squeaks.

Female Speaker 2
This is a really cool toy Scarlet. I want you to play with it and see if you can let me know how it works. Can you let me know when you're done playing with it?

Alison Gopnik
Okay, so what she does is, as you'd expect from the previous experiments, is she just starts exploring the toy. And she tries everything she can. Not to cut this short, but she figures out how the squeaker works. She figures out how the light works. She figures out how the mirror works. She figures out how the music works. All right, now this time it's almost exactly the same except this time, the grown-up is going to be a teacher. So this time instead of saying, "I don't know how this toy works," the grown-up says, "I'm going to show you how my toy works."

Female Speaker 2
Hi, I'm going to show you my toy. Isn't it cool? Okay, I'm going to show you how my toy works, Isaac. Did you hear that? Can you let me know when you're done? Okay, great.

Alison Gopnik
Okay, so she showed him the squeak and sure enough, he's making it squeak. And he's making it squeak some more. And we can keep showing you this film for the next five minutes and what you would see is that he never does anything except the thing that the teacher showed him that he was supposed to do. So when the teacher was actually acting like a teacher, the children didn't show this very wide-ranging exploration. Instead what they did was narrow in their search to just the thing that the teacher had shown them. So in some ways that's a very smart thing for the children to do. They're really sensitive to quite subtle things about whether someone's trying to teach them and it makes sense if you think someone's trying to teach you to say, "Okay well they know better than I do. I'll just imitate exactly what they do." We've seen this in my lab as well, but what it means is that the kind of teaching that people can do can actually be narrowing that exploration which is what the children are designed to do. So it's a real dilemma for us in developmental psychology because when people hear how amazingly good these babies and

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children are at learning, their first impulse is to say, “Okay what we should do is be teaching them more and more.” In fact, that’s exactly the opposite of what the work shows. So instead of preschools being more like schools, which is increasingly the direction that things are going, schools should be more like preschools. So if we actually want to have adults who are going to be sensitive to innovation and novelty and variability and change, which is really our human inheritance. That’s the thing that we humans were designed to do. The thing that we adapted to was not having anything specific to adapt to. What we adapted to was things change, they’re unexpected, new things are going to happen. We need a new generation of children each time to figure out how to deal with all of this unexpected innovation. And that hasn’t stopped. If anything that's more true in our lives now than it is before and what we’re doing in our educational system, especially with preschoolers, is exactly the opposite of what evolution did in making us human in the first place.

So I hope what I've persuaded you of is that those preschoolers who the philosophers didn't even mention in the two thousand pages actually are in some ways more human than we adults are human. They’re giving the kind of purest taste of those capacities for imagination, creativity, exploration that are the things that really make us so distinctively human.

Meredith Johnson
Thanks for your feedback on the last live episode. You can let us know on Facebook, or with an email to Origin Stories and Leakeyfoundation.org if you’d like us to keep posting these. We tweet at @originspodcast.

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