PROFESSOR: Last time I was talking about cognition and I'm framing the argument in part in saying that we're not like computers, even though computer's a nice metaphor for various secure aspects of cognitive function. We could continue that today. When you get an off-the-shelf computer, you expect that its basic way of thinking is going to be -- it's there. You might have to put some programs on it to teach it to do specific things, but you don't have to educate its motherboard or something of that sort. With kids it's not clear that that's the case. That if you take an off-the-shelf baby, it's not clear that that baby is thinking the way that an adult is thinking. That's really what I want to talk about today.

Let me put up a picture that I can then return to multiple times. If this is age, and we're interested in development, what we were talking about last time is the adult state -- something about the adult state. What we want to know in studying cognitive development or any sort of development is what's the starting point? If you have a newborn baby, is that starting at zero or does that baby come with some sort of innate endowment that gets them on the way towards the adults state. Then what does the transition from the kid state to the adult state look like? Does it look like some sort of gradual improvement? Does it look like some sort of step function? It might be useful to describe from the realm of vision, a couple of examples just to show you what this means. If you want to know what a baby sees, get yourself a newborn off-the-shelf baby and give them -- well, you can't give them an eye chart to read because they can't read, so you give them the illiterate E chart, as it's called in the trade, and you ask them which way do the letters point, the kid doesn't tell you anything useful, because the kid can't answer that question.

However, conveniently enough if you take even a newborn baby, young as you can test them, and put them in front of a couple of screens -- little peephole here. You guys can all be babies and the experiment, if you're looking out at you through this peephole, if you put black and white bars on one screen and you put on the other screen a grey of the same average luminance, so if this is zero and that's 100, this is 50 all over the place. If the baby can see the bars, conveniently enough that baby will look at the bars. If you are looking at the baby, you can figure out, you move the bars from side-to-side from child-to-child, you can figure out where that baby is looking and you can figure out where the bars are based on where the baby is looking. That's known as a preferential looking method, very useful in infant research. What you discover, if you do experiments like this studying infant visual aquity, is that babies don't start at zero. A newborn baby isn't blind. Newborn baby can see something. If normal adult vision's around 20/20, newborn baby vision is around 20/400 -- the big E at the top of the eye chart roughly. The progression from the infant state to the adult state is a gradual, relatively steady increase over about the first couple of years of life. Every month you get roughly the same kind of improvement until you hit the adult level. So, not a zero starting point and a gradual improvement to adult level.

Now let's take a different example from the same realm. Remember you've got two eyes, the differences in those two eyes are a depth cue -- known as binocular stereopsis. Well the cue is binocular disparity, the ability is stereoscopic depth perception. If you test a baby, so baby's it turns out also like things that stand out in depth better than they like flat stuff, so if you show a baby bars standing out in depth, a newborn baby gives you squat. To all appearances there is no binocular stereovision in a newborn baby. For about the first three to five months, nothing happens. Then over a very short period of time, performance rises to essentially the adult level, as if this was waiting for something to get wired up in the brain. When it got wired up in the brain, bingo, the kid is fine.

Oh, by the way, if you are a woman person you got there first. It turns out to be a reliable sex difference that females get binocular stereovision a month or so before males. Does this make any difference to anything? No, but we found it years and years ago when I was a grad student so I still remember it. So these are two of the various possibilities for a function like this for a developmental course. We're going to talk about three specific realms of cognitive development in which there are classic demonstrations of children doing things differently than adults do them. I will try to take each of those apart and to give you some idea of what's the starting point, what's the ending point and how do we get between those. The three, which are outlined on the handout have to do with so-called childhood, animism and egocentric behavior. Let me describe each of these problems to you in turn and then we'll take each of them apart. These are all demonstrations that originally come from the work of Jean Piaget, the great early mid-20th century developmental psychologist, who among other things, bequeathed to us a great collection of phenomena that shows striking differences between the way kids behaving and the way adults behave and that cry out for explanation.

So here would be one of them. These are M&M's, let us say. This is another one of those forced choice kind of things, so think hard about this. Are there more M&M's here or here? How many vote up? That's good. However, if you were 3, 4, 5, maybe even 6, you'd say here. You would be perfectly happy. So the first obvious thought is well, the kid's just not quite understanding the question. It a languagy kind of thing. We're saying where's more and they're saying which is longer. So that's why it's important that you use M&M's. You say OK, kid, which pile would you like? Kid says I want this pile. Why do you want this pile? Well there's more there. In fact, this is why you shouldn't be born to a psychologist because your psychologist dad is always tricking you out of the candy by playing this game on you. It works. You teach this stuff long enough and you say is this really true? And then you've got yourself like a three-year old kid and you mess with his brain -- yeah, it's true. This is good stuff. The question here, of course, is then what's going on? This is part of a general problem. So let's take a fat beaker. Here's a big fat beaker with this much fluid in it. Now I pour that into a narrow beaker. The fluid level is?

AUDIENCE: Higher.

PROFESSOR: Higher. Is there more fluid now than there was when it was here? No. Does a little kid think there is? Yes. If you let the little kid pour it back into the big bowl, now he thinks there's less now. Take a ball of clay, roll it out into a snake, there's more clay says the little kid. Squish it back together, now there's less. These are so-called conservation problems. We're particularly interested in the version that has to do with number -- how come they think, in this case, that five is bigger than six.

Second problem is what's called childhood animism. The classic Piagethian version would involve something exactly like his so-called three mountain apparatus where e had sort of a table top -- he's from Switzerland, so he's into the Alps. It's a table top version of the Alps, on the Alps are things like, that's a river and that's a hut. The point is that you're sitting here looking at this thing. You're like a three-year old or something looking at this, and mom's over there on the other side. You can see mom. The question that you're asked is can your mother see the river? And you say, yeah sure. As if the fact that you could see the river makes you think that she can see the river. As if you couldn't take her point of view. At least Piaget thought that the problem here is that you can't quite take somebody else's point of view.

My favorite anecdotal version of this is a story of a little kid out to eat with his brother at some burger place. Little kid wants more French fries, and so he does this, on the theory, presumably, if I can't see what I'm doing, you can't see what I'm doing. Most people don't do that by the time they reach adulthood. So there's something to explain there. That's not childhood animism at all. Actually, that's egocentric behavior. Sorry, I misspoke. That's the third example that we'll get to. So, egocentric makes more sense. Ecocentric is the inability to see things from somebody else's vantage point. So I've just described to you the problem of childhood egocentrism. Childhood animism is a tendency to declare things to be alive that you would not declare to be alive. Is the cat alive? Yeah, fine. Is the sun alive? Yes. Are the clouds alive? Yes. Little kids will assert that and you typically will not. That's animism. Piaget understood that as a problem with mapping concepts onto a discrete set of entities out in the world, and so we'll take a look at that, too.

So, number, animism, you egocentric behavior, those are the things that I want to talk about today. Let's start with number, and let's start by taking apart the idea of number a bit. Because you an I tend to think of number as there's five of those things and six of those things. The concept of number, the idea of number can be broken down into three different bits at least. Let's see if I can do this right. Oh, well they went by. How many warthogs were there?

AUDIENCE: [INAUDIBLE].

PROFESSOR: Let's try this again.

AUDIENCE: 7. 8.

PROFESSOR: 9, 8, 7. Some number like that. It wasn't 150. But how about this?

AUDIENCE: 2.

PROFESSOR: OK, that's good. How about this?

AUDIENCE: 3.

PROFESSOR: How about this? This is data. If you do this task, what you find is that people are essentially perfect for 1, 2 and 3, maybe 4, and then it falls off. I think the answer was 8 before, but sometimes you say 7, sometimes you say 9, and so your percent correct, being absolutely correct will systematically fall off. If I put 1,500 wart hogs up there you'll just not get it right at all. Similarly, if I was to measure not percent correct but reaction time, the reaction time for 1, 2, 3, 4 would be essentially flat, and then start to roughly linearly increase. That linear increase could be, for a number like 8, could either be due to some sort of counting operation.

Somebody who thinks they saw 8 of them, tell me how they figured that out? Yeah?

AUDIENCE: You saw a line of 5 and then 2 and 1.

PROFESSOR: A line of 5 and 2 and 1. OK. Yeah?

AUDIENCE: I couldn't get a count because they went away.

PROFESSOR: OK, yes. If I was doing this as a proper experiment I would have masked it so you couldn't count like the after-image or the iconic memory. Yup?

AUDIENCE: Just recall the picture.

PROFESSOR: OK, so you were also dumping it out of iconic memory in some fashion. The answer I was fishing for is something like the 5, 2 and 1 thing. That you can count those displays, and in fact, the people who got them back later might have done this, too -- by more typically saying oh, there's one group of 4, there's another group of 4. This ability to handle small numbers is called subitizing, and it works for small numbers like 1, 2, 3, 4. You have some immediate appreciation of those small numbers that's different than your appreciation of 8 or 17 or 150. That's one wart hog demonstration. How about which one has more wart hogs? How many vote that there were more here? How many vote that there were more here? OK, you got that. How many wart hogs were there here? A lot, yes. And how many wart hogs were here? A lot but not as many. You could count these, obviously. But you didn't count them and you didn't subitize them. What you did was you got some sort of general impression of their numerosity. This is if you go back to perception chapter, this is another Weber's law kind of thing, or the money example from last time.

You can also decide something about how many things there are there by a sort of a ratio comparison. There's more here than here. If there were 750 here and 745 here you wouldn't know that. There has to be a critical proportional difference between the two. But given a proportion difference, that this is something like 2:1, like that, it doesn't matter how many things there are, you simply know that there's more here and less here. That's sort of a crude sense of numerosity. What we typically think of when we think about number is counting things, and that's the third property. So here, you can count them. Somebody can go and figure out exactly how many wart hogs there are there. You just have to go through and use your counting ability to figure that out. You have that ability. It seems to be critically piggybacked on linguistic ability.

Recent interesting evidence for that comes from -- I don't know how to pronounce it properly, but something like the Bari Rahua tribe in the Amazon. Their number terms consist of 1, 2 and more than that. The result is that they bomb tasks that require counting. They can do subitizing tasks, they can do numerosity tasks, but they don't do counting tasks. They fail versions of the M&M task in effect. You say which of these boxes do you want -- the got fish in them or something like that, and one has a little label with 4 fish on the top and another has 5 fish on the top and as far as these guys are concerned, it's all just got lots of fish. What you see here is a task where this was the experimenter's marks, and the Bari Rahua person was asked to just copy it. So, one mark, make one mark, two, I can make two marks, three, three. That's just a bunch, I'll make a bunch of marks. Once you got out of the subitizing range they simply didn't do the task. I think I'd put these guys on this article from which I stole -- this picture may live on the website. I seem to remember that that was one of the things that I posted there.

So, what to kids have and how does that tie into the M&M problem. Well, turns out that little kids have babies, have this numerosity -- Weber's law, comparison kind of numerosity ability, and here's an experiment done by [? Shew ?] and Liz Spelke up at Harvard that illustrates that. You're a baby, you're looking at this, and every now and then the display changes. OK, there's another bunch of dots. And another bunch of dots. What I'm doing is I, the experimenter am measuring how long you look at this. I'm changing the shape and the distribution of these guys, but I'm not changing the number. You are slowly getting bored, or to be more technical about it, you're habituating. You may recall that from the learning chapter. I don't think we talked about it in the chapter. Well, we can talk about it right now. A bunch of people oriented to that. Now those people are having no problem at all veeing back out again. That's habituation. You do it, babies do it, slugs do it, everybody does it. Great. Useful technique, because the baby's sitting here saying this is all kind of more or less the same and it's just not that interesting. Wait a second, that's interesting, says the baby. And the baby says it by looking more. What happens here is that looking time goes down, down, down, down as the number on each trial stays the same. Then when you jump from 8 to 16, the baby says hey, something's happened, I gotta take a look at this. Do 16 for awhile, blah, blah, blah, blah, blah, blah, blah, blah. What this tells you is that the baby could tell the difference between 8 and 16. The reason for changing the shape and the distribution and the density and stuff like that is to make sure that that's not what you're picking up on. [? Shew ?] and Spelke were careful about that.

So what you're picking on here is numerosity. Babies can do that, but if you go from 8 to 9, nothing happens here. In fact, if you go from 8 to 12, a 50% increase in dots, nothing happens here with, how old are these babies -- six month old babies. So, 8 to 16, a 2:1 change -- that babies pick up on. So, one thing we know that if we're talking about number, the starting spot isn't zero for number sense in infants. The numerosity piece, some chunk of the numerosity piece is there for starters. Perhaps more dramatically, the subitizing piece is there, and the subitizing piece is there along with what seems to be an innate mathematical ability. Little kids can add and subtract. Babies can add and subtract. This was a surprise. This is work done by karen Wynn, and it is worth making the historical note that she was a TA for this course once upon a time, now a professor at Yale. But in any case, she figured out that babies can add and subtract. Look, if you ask a baby what's one plus one, you get much the same answer as if you asked the baby which way is the E pointing. You gotta get clever about this sort of thing. Here's how Karen got clever about it. So, you're looking at a screen. You're a little baby looking at a screen like this and you see a hand come in with an object. And you see a hand come in with another one. You got a pretty good idea what's going on here, right. So, if I lift the screen, what do you expect to see? Now, we're going to do this again. The speed would be the same, of course, I just didn't want to keep sliding them in slowly. The baby will respond to this by looking longer. The baby will say -- who knows what the baby will say, but the baby is apparently in effect saying put one thing in this, two things in here, two stuff, two wart hogs back there. Now there's only one wart hog and this violates the rules of the universe and I said better look at this for a while to figure out what's going on.

You can use this technique to show that babies can do -- do I have a subtraction one here, I forget. It works for monkeys, too. We'll talk about that in a minute. But you can do addition, you can do subtraction. So, subtraction, you have the two things here, you put down the screen, the hand comes in and pulls one out. When the screen comes up the baby expects to see one. If the babiy sees zero or the baby sees two, the baby says something weird's going on here, I need to think about this for a while. Now, if you do this with big numbers outside of the subitizing range, you don't get the result. So, you stick 15 wart hogs back there and you lift up the screen and there's 13 wart hogs and the kid says I don't care. Once you get above about 3 with babies, it doesn't work anymore. So, what you get is evidence for subitizing being present and some sort of addition and subtraction kind of operation for, essentially as early as you want to test it.

You can also get these abilities in animals -- that's what this slide is intended to remind me to tell you. Animals, certainly Macaque monkeys will show numerosity effects, and they can also do this sort of Karen Wynn style math. They prefer eggplants -- at least Marc Hauser's monkeys like eggplant, so that's why there are eggplants here. And you worry about doing this in the lab, because maybe your lab monkeys have led this elaborately studied life and are kind of smart. Hauser went down to this island in the Caribbean where he's got a free-ranging troop of monkeys. Then you kind of have to coax them into playing your game. There's this great video that Marc has of monkeys -- he's hanging out with his eggplants, then he's starting to do this eggplant puppet show with the Macaque's looking longer at the weird ones. The guy put two eggplants there, there's only one there now. Hope he's going to feed me some of these eggplants eventually. But in any case, monkeys can do the task. Monkeys will look longer at things that violate their expectation.

However, monkeys don't count. At least they don't count the way that you and I count. This goes for great apes. Fine, let's go find the brightest beast other than humans that we can. There's at least one chimp who's been trained for 20 years -- oh, I misspoke when I talked about this in Concourse. I'd said he'd been trained for nine years and never gotten past 20. It's worse than that. He's been trained for 20 years you never gotten past nine counting. He can count to nine, do pretty good stuff up to nine. But he's doing this by basically association learning. You can train the monkey to realize that this sign or this graphic or something means nine things. But this is very different from what you and I can do. It didn't take you 20 years and you got well beyond nine. Counting seems to be heavily dependent on two things. One is language, and the other is an act of inductive reasoning. You can sort of see counting happening, the development of counting in a series of steps. Kids, as they are learning language, learn that there is this kind of game about saying 1, 2, 3, four and so on, that parents really like to play. If you start counting they'll give you the cookies and stuff. Good things happen.

They don't have any particular clue initially that this maps on to anything in particular. So, what you get with like two and a half year old kids is a two and a half year old kid, if you ask for one cookie will give you one cookie. But if you ask for anything else -- give me two cookies, give me four cookies, give me whatever, they'll give you some random -- here, have some cookies. It's one and other stuff. Eventually they learn to map the counting onto the subitizing range and then start blowing it later. If you have little sibs or cousins or stuff that you've hung around with, you may have seen them counting things -- 1, 2, 3, 4, 5, 7, 12. They got this notion that the numbers keep going in some fashion, but once you get out of the small numbers it's not terribly clear what's going on there. But even in this stage you can start to see the development of something more sophisticated. Six -- they may not know how many six's, they know six is a lot of stuff. If you ask for six cookies you'll get some arbitrary number of cookies. But if you ask a little kid if I take a lot of cookies and I add a few, do I still have a lot of cookies? Kid says yeah, it works. So, alright, so we know that. Now, if I have six cookies, can you give me six cookies? Some random number of cookies. If I have six cookies and I add some more cookies, do I still have six cookies? No. You got a lot of cookies but it's not the same a lotta. So, even when they don't really know how many cookies you've got, they have the notion that the number names are naming something specific. They don't quite get what it is, but it's something specific in a way that a term like a lot is not.

Eventually, you make the breakthrough that you can count, basically, and if you add one to each of them you can just keep doing this forever. Again, I don't know how much you hang around with little kids or remember your own experience, because this is getting old enough that you might actually remember this state yourself, of asking what the biggest number in the world is. Anybody remember asking what the biggest number in the world is? That's the problem with MIT students, right, they figured all this stuff out when they were like two. So anyway, little kids want to know what the biggest number in the world is, and so you say to the little kid, well what do you think the biggest number in the world is? Well, it's a million. OK. What happens if we had a million plus one, is there a number for that? I guess a million and one's the biggest number in the world. Well, [UNINTELLIGIBLE] add a million and two. You can keep doing this for a while.

Eventually, around the time when you get in this conversation, the kid catches on to the notion that you can always get a bigger one. This is really the very boring car rides sometimes. Do you want to see how high I can count? That's a kind of cute game with a three-year old. Aw, look, he can get all the way to 20. By the time you get a 4 or 5 year old, million and one, million and two, million and three. OK, we've made it to California kid, shutup. What you get is you've got this basic numeric competence or core knowledge, as Liz Spelke would call it. Then you're waiting for the development of language. When you get language you can then get this counting piece to work. When you got the counting piece to work, you can combine it with your ability to make the inductive leap that numbers go on forever. Then you're in a position to go off to school and learn some math. There's, in a sense, not an adult level of numerical competence. You guys know more about numbers than I know, I would imagine. But the ability to go off and learn that kind of math is based on this core knowledge, then waiting on language before you can make the leap to an ability to do 180 whatever. So, it's an example, if you like, of the synergistic combination of information from a couple of different realms.

Let's switch to the problem of childhood animism that, if you're not completely confused from my earlier mis-speaking, animism is the tendency to say is the sun alive? Yes. Are clouds alive? Yes. That seems quite different from what you and I do. One might wonder exactly how different it really is. Does it really reflect a fundamental problem with the concept alive? It's not that's obvious how you map the concept like that, even as an adult. This is perhaps easier to think about in connection with dead. Mapping dead onto a discrete set of things is not that trivial. Is a rock dead? Probably not because it was never alive, right. Is George Washington dead? Seems about right. Is he dead in the same way that something that you can, like a cat that just recently died -- the here, dead, now. Is that's the same? How about a dinosaur? Or the dinosaurs, are the dinosaur's dead? Well yes, they're dead but they're also extinction, which is somehow kind of different. Or to use an example from driving around, now that my kids have gotten out of the counting to a million stage -- I don't know how we got on the subject of what is alive. Maybe because I was thinking about this lecture. But anyway, my 10th grader asked my 3rd grader is fire alive? Well, I don't know about the 3rd grader, but it took dad in the front seat a surprisingly long time to figure -- dad knew that the answer is no, but the principled reason why it's no, took me a couple of beats to get to. Because fire breathes, right, it grows, it reproduces, it can die, it can do all those good things. Turns out that in 10th grade biology they teach you that if you're going to be alive you've gotta be made of cells, and fire's not made of cells, except that then you get into 11th grade English and you read some sci fi novel where this thing is alive but it's just a forcefield in deep space or something like that. I don't know what to do about that.

Concepts like alive are pretty complex stuff, and the fact that a kid doesn't map it exactly the same way you map it may not be that definitive. Does the kid have a concept at all that they can use? That's what we really want to know. What's really going on there? So maybe we ought to ask the question a little bit differently. Kid had some notion of what alive things do. So suppose we ask a kid does a cat breathe? Yeah, a cat breathes. How about a cow? Yeah, a cow breathes. How about the sun? I don't think so. The moon? No. The clouds? No. And you can do the same thing with babies. Not asking the babies, but talking about can a cat have babies? Yeah, sure. Can the sun have babies? No. You get the feeling that there's a concept there that they're just not using the word alive the way that you and I are using it. Well, maybe all you're looking at here is the fact that they don't actually have a concept. What they have is a long list of learned instances. They are hang out at these fancy upper middle class preschools where they get taught kitty has babies, cow has babies, and they never gets taught sun has babies, because the sun doesn't have babies. And so they learn all this stuff. Maybe it's not a concept, maybe it's just a list of instances. How can we figure this out?

Well, Sue Carey did an experiment where what she did was she taught kids something new. She said see this cat? This cat has an omentum. And you have an omentum. And the cow has an omentum. Now, how about the sheep? Think it's got omentum? Probaby got no mentum. And the dog? Yeah, the dog's probably got one. How about a fish? Yeah, probably, could be. Worm? I don't know. Rock? No, rock doesn't an omentum. How about sun? No, sun doesn't have an omentum. You don't have one either it turns out. She wanted a real biological term, but I think it's some weird membrane that an insect has or something like that. But the point was that it wasn't something that you would have ever learned. It's a new piece of knowledge, and if you say that things in this category, things in the category that are encompassed by cats, cows and you all have this, who else has it? And little kids, three, four-year old kids, map this in a plausible kind of a way. It might map something like mammal, it might map something like animal. I don't remember if any of her kids mapped something like alive in which case they would assert that a tree had it too or something. But it maps a concept that has a biological ring to it.

What's the difference between the childhood use of these concepts and the adult use of these concepts? It seems to be, in this case, education. You go to school to learn the right concepts. In this sense, there is no firm adult state. My job here is to teach you a collection of facts and the right concepts in psychology. But I can teach you some of them and I keep learning new ones, and the adult par keeps sort of drifting there. You sort of go off to learn these sort of concepts. But you don't learn to have a concept per se. What the kid is doing -- well, actually it's rather similar to what we're doing here. The kid is mustering the data that is available to him, and working with the concept--. So what do you think the concept of alive is for a little kid? What do you think goes into it that causes little kids to give the wrong answer when asked by Piaget what's alive and what's not? What's the critical difference between your notion of alive that you picked up in 10th grade biology and a four-year old's notion of alive? Anybody? Yup?

AUDIENCE: Something alive is something that moves and you didn't see how [INAUDIBLE].

PROFESSOR: Yeah. So moving on its own seems to be an important--. So cars aren't alive because you've got to make them move in some fashion, but self-produced motion seems to be an important part of the definition, and the sun and the clouds and the moon seem to scootch around in the sky, particularly if you're driving in that car, in ways that suggest that it might be alive. It gets a little more complicated because kids have also learned that trees are alive, and outside of *Lord of the Rings,* trees don't do much in the way of wandering around, but growing on your own is good, too. But that would be part of the biological definition. It's the self-produced motion thing that kids overuse in their definition, seemingly, that you don't use. You can see if you get transcripts of little kids using language, you get a feeling for this little scientist aspect of childhood concept. Well, concept formation, concept verification. So, here from the what is alive literature is a kid who is asked are rocks alive, and the answer is yes, rocks are alive. But they're only alive until you step on them and then they die, which is kind of reasonable, right. The kid's got presumably some experience with other things like that. This ant -- the ant's alive, I step on it, it's not alive anymore. And this kid produces some evidence in favor of this theory, which is if you look on a path, how big are the rocks on average?

You could take a walk in the woods down a rocky kind of path, there are rocks on it, they're kind of small rocks. You look off across at the mountains, how big are the rocks? They're huge. What's going on here? Well, on a path people are walking all the time so the rocks die real young and they never get to grow big. Whereas the rocks off the path out in the mountains, they got to grow to be really big rocks. It's not a correct theory, but you can see the kid using the data he's got. right, a certain amount of data there. If I step on it, it dies. Maybe that's what happens to rocks and people step more here than they step there, so big rocks, little rocks. It all hangs together. I got a great theory here. Another one, are rocks alive? Yes. Can they have babies? Yes. Are all rocks alive? No, some rocks are dead. How can you tell if a rock is dead? Well, the dead ones just lie there. This is capturing the notion that motion is important in little kids' definitions of the notion of aliveness. I don't know how many rocks you saw moving under their own power. In any case, you can see the little scientist aspect of this.

OK, so what's the starting point here? The concepts that you're building seem to have some foundations that can be picked up very early and are probably innate. I'll just talk about two of them here. So concepts like about things like aliveness. If you're going to decide that a thing is alive, you need for starters to know that it is a thing. So you need to have some notion of an object. The other thing you need is some notion that objects, classes of objects, have essences -- I think it's on the handout somewhere as -- towards the bottom of page 2 says essence and there's a reference of Susan Gelman's work on psychological essentialism -- the notion of an essence is a property that's not visible or at least not currently visible. In order to have these sort of category things, you've got to have the notion that objects continue to have properties even if you can't see that. So, for example -- well, I won't embarrass anybody -- but there are people here presently who are not moving, who are not, to all appearances, growing. I can't tell from this distance whether they're made of cells and they don't appear to be having babies or anything like that. Nevertheless, I assume that they are alive. That's part of their essence. That this aliveness is something that I attribute to that object without being able to see it. Now what's the evidence that little kids have that? Well, I'll tell you that and then we'll have a break and then we'll go on to the problem of egocentric behavior.

Let's start with evidence that babies know something about objects. Here's a tube. If I was doing this right, I'd show you that there's nothing in the tube. And then I would take a stuffed animal -- he's a duck. we take the duck and he's a squishy duck, so I'm going to stuff him in the tube. So the baby's watching all this cool stuff happening here. There's little babies watching this stuff. Then I take Nemo or whatever, my little plush Nemo, and I stuff him in the tube. You with me so far babies? Now, I reach into the tube and I pull out the fish. And you, being good babies, stare at this. You say this is weird stuff because I saw the duck go in first -- this is not quite Spelke's experiment. I realize I'm getting the methods a little screwed up but the principle is right. I saw the duck go in, then the fish went in, and I know about objects. Objects do not interpenetrate. Objects are solid things. If the fish is out here, where'd the duck go?

Spelke's done a series of experiments like this that suggest that kids know about object -- babies, young babies, as early as you can successfully test them, so getting very close to being at the starting point -- know about objects, and know a few things about those objects. Notably things like that objects don't interpenetrate. They don't know everything about objects, so they don't, for instance, if you set up some fish and ducky kind of thing that violates the law of gravity, kid doesn't care. They don't seem to be particularly sensitive to gravity. Yet a two-year old in his high chair -- two-year old in the high chair thinks gravity's great. Here's the hot dog. OK, so dad picks up the hot dog and puts it back on the plate and the kid drops it again, because he's a little scientist, right, you gotta check that gravity is still -- you'll get there. Marrah knows about gravity but her baby doesn't know about it yet. Her baby looks at gravity demonstrations and says this is really boring. But her baby knows that the fish cannot go through the duck. It just would be bad news for the duck. Babies don't care about inertia either. Things like object in motion continue in motion unless acted on by--. Tell that to a baby, the baby says yeah, right. Don't care about that. But I know that that fish does not go through the duck. So that's this notion of objects.

What about essence? Well essence is harder to get to in early childhood. It's harder to ask the question, but by the time you get to -- how old are we in this experiment -- you're like two or three years old, but you're doing something like this. You take the duck and you say see this duck, what we're going to do is we're going to do an operation on the duck. I promise it's not going to hurt the duck. But we're going to take off his skin and we're going to put raccoon skin on him. He's going to look just like a raccoon. OK, is this a duck or a raccoon? As soon as the kid can meaningfully answer the question for you, to kid will say that's a duck. I mean you dressed him up like a raccoon but he's a duck. Inside he's got duck essence -- he doesn't say anything about duck essence, but he knows that there's a core of duckness that is not dependent on looking exactly like a duck. How many of you are familiar with the classic Pepe Le Pew cartoons? Yeah, it's Cartoon Network stuff. The basic plot, there's a whole bunch of these, but the basic plot is always the same. Pepe Le Pew is a French skunk, a French lover skunk. And this cat, female cat, gets a white stripe down her back by some paint or something like that and Pepe spends the next five minutes of the cartoon chasing her around trying to get her to fall in love and she doesn't want to fall in love because she knows he's a skunk and she knows that she's not a skunk. What's funny about this, the reason this is funny for little kids, is that little kids know that the fact that she's got a white stripe down her doesn't make her into a skunk. She's still a cat who happens to look like a skunk and isn't that funny because the skunk is chasing around after her and getting hit in the head with bats and stuff like that, and all the good things that happen in cartoons.

So, not only do kids know that things have an essence like that, they are also, to be a little recursive here, they're innate nativists it appears. They believe that these properties came with the system and were not learned. So, Susan Gelman did a clever experiment where what she did was she said, see this kangaroo? Take this kangaroo -- this is a baby kangaroo, it's a newborn kangaroo, and you know what we're going to do, we're going to take care her and we're going to give her to the goats and she's going to get raised by the goats. Now she's all grown up. Let me ask you a few questions about her. Does she have a pouch? Well, yeah sure, that's pretty straightforward. That's not the interesting question. The interesting question is is she going to be hopper or a climber? And little kids -- two, three year old kids will say it's going to be a hopper. It was a kangaroo at birth, kangaroo's hop. It's part of their essence. The fact that she lived with the goats isn't going to change that. This is the amusement value of the Disney Tarzan cartoon, right. Tarzan gets raised by the gorillas. Have you seen that?

Oh man, when did that come out? I got to calibrate my Disneyness here. Which Disney movies came out when you were of an age to watch them?

AUDIENCE: Alladin.

PROFESSOR: Alladin. Oh, you were too old when Tarzan came out. You're the Alladin cohort. Jungle Book came out when I was a kid. Well, no not quite. The ones that came out when I was a kid were things like Sword and the Stone, I thought that was great. That was good stuff. And don't claim that I was a kid when Snow White came out -- that was my father. So, Jungle Book works, right, and you get raised by the wild animals, but you're essentially a human and that eventually catches up with you. Actually, kids are incorrect nativists because they believe things that turn out -- and it's true that the kangaroo will probably hop even if it gets raised by a goat. But suppose we have here a Chinese baby and we take this Chinese baby and we bring it to the United States and it's raised in California. When that kid grows up, will she be able to speak Chinese? It depends on the--. What?

AUDIENCE: [INAUDIBLE].

PROFESSOR: It depends on the neighborhood. But kids aren't quite clear on these demographic issues in the same way. But a little kid will figure incorrectly that language is one of these essential properties. That if you're Chinese, that means you can speak -- you might be able to speak English, too. You could learn that, they can figure that out. But you'd have a privileged ability to speak Chinese because after all, you were a Chinese kid and that ought to work. If you're a Chinese kids who grew up in an Anglo linguistic environment, you may have discovered that there were plenty of your relatives who also thought you should be able to speak Chinese, but that's a different issue.

In any case, little kids start certainly with the notion of objectness and probably quite early with the notion that objects have essences, and then they bild on that in this little scientist kind of a way to get closer and closer to what we consider to be the adult concept of whatever, alive or kangaroo or any of those sorts of things. Here's the case where the adult state is not particularly fixed, but we're nevertheless, what you're doing is you're elaborating on juvenile concepts, not suddenly discovering the notion that there is such a thing as a concept.

OK, I want to do egocentrism still, but I will start doing that when that thing says 3:10.

BREAK IN LECTURE

Let us talk about egocentrism. So, you will recall that the basic problem here was that the kid seemed unable to take the point of view of another, in this case, the mother on the other side of this table. The kid asked about things like the river and the hut, claimed that the mom could see them, even though mom couldn't see them, only the kid could see them. You can get kids to perform quite well on this task if you come from like Nebraska instead of coming from the Alps. So, in one version of this experiment -- so I think the answer is that four year olds failed this. You can get three-year olds to be successful in an equivalent task, if what you do is just simplify the situation. So there's a version of this that may have a picture in the book still, I don't remember, of sort of a city block with a car in it and a Sesame Street character. You drive Grover around the block or something and ask questions about that much simpler situation. Then the kid can successfully answer questions from the vantage point of the mother, as if part of the issue here was that the task was just too complicated.

Oh, I never mentioned the M&M's are under there somewhere. I never mentioned well why is that the kids bombed the M&M task. That seems to be an issue where you're asking kids who haven't gotten to the successful counting stage to do this and they can't do it either with the numerosity or the subitizing piece, so they fail the task. If you make the M&M task, if you put that into either the numerosity range or the subitizing range, little kids will succeed in doing the task. So if you say would you rather have this pile with two M&Ms or three M&Ms, little kids don't bomb that. They bomb five versus six or six versus eight, things like that. And a similar sort of thing seems to be going on here that the task is in some fashion a little too complicated for them. How far can we push this back?

Well, if you take two year olds, suppose you take two year olds and you give them a pair of sunglasses. Put the sunglasses on the kid, kid looks around for a while. Now we take the sunglasses, they may have been mirrored shades even. Put the sunglasses on mommy and you ask can mommy see you? Well, you can't see mommy's eyes anymore because of the glasses, but the kid, even a two year old will be able to say yes, indeed mommy can see me, even though I cannot see mommy's eyes. Normally, if mommy is doing this, it's a pretty good bet that mommy can't see you. That's the root of a lot of entertaining games. But they can manage to solve the problem, if it's simplified to the point of sunglasses on or off. This if I can see you, can you see me thing, you can see, as you get more and more complicated, that it takes you longer and longer to solve the more and more complicated versions of it. You don't remember what it was like to be thinking when you were a two year old, but you may remember a stage later in your life when it was not clear to you how mirrors worked. That if a can see b, b can see a in a mirror. This is the sort of thing that amuses early school age kids often. I can see around the corner. I can see dad around the corner there. I bet he can't see me, and it comes as a shock that dad can see you, because the mirror kind of works both ways, and then there are more complicated arrangements with keyholes and stuff like that where it takes even longer to be able to take the point of the person on the other side.

So, some aspect of this is simply a matter of complexity. In fact, Paul Bloom and his student -- actually, I should mention Paul Bloom is married to Karen Wynn. They were both TAs for this course and are now both professors at Yale. Anyway, Paul works on similar sorts of problems and talks about the curse of knowledge that shows up in adult behavior, too. That it's very difficult, it's often very difficult to remember that somebody else doesn't know what you know. So, it's a problem for me teaching. The things that are hardest to teach are the things that I don't know anything about. That's not surprising. The second hardest category are things that I know too much about, because it's hard to remember how little you know about vision. How can it be that you haven't actually spent the last 18 years of your life bathed in visual phenomenology. You can try using that as an excuse on the exam but forget it. We'll still take the points off. That turns out to be an example of the curse of knowledge. Or another example would be if you've ever been giving somebody directions while you're sitting next to them in the car, you might discover that you go past the street where they were supposed to turn because you knew you were supposed to turn there, and you just kind of forgot that they wouldn't know that and that's why you were sitting there supposedly giving them directions. It's hard, even for adults necessarily. It's hard for adults sometimes to take the vantage point of another person.

Now one of the great examples of this in kid behavior, a paradigm that's yielded an awful lot of research. This gives you some insight into this, if you like this curse of knowledge problem, is what's known as the false beliefs task. The first false belief you need is that this is Big Bird from Sesame Street. So here's how a typical false belief task experiment might work. You're watching this. Big Bird comes in to the scene and he has candy. He puts the candy in the refrigerator and he goes out. Now, I didn't draw Grover or whatever, but Grover comes in, takes the candy out of the refrigerator and puts in the drawer. Now, Big Bird comes back in -- he didn't see this abut you saw this. Big Bird comes back in and you are asked where will Big Bird look for the candy? And your answer, if you're like a four year old, is that Big Bird will look in the drawer. You cannot somehow access the fact that Big Bird thinks in his brain that the candy's in the fridge. When you updated your knowledge about the candy, you updated his knowledge about the candy, too, in some fashion.

Now there are endless versions of this experiment. This is a task that younger than four will fail, older than four roughly will tend to get. There are endless tasks that look at this and try to break it apart, see what's going on here in developing this ability to take into account what is in the mind of another person or bird, as the case may be. This is sometimes talked about as mind reading and is sometimes described as the major social problem in autism. That maybe one of the reasons that autistic kids and adults have a real problem relating to other people is an inability to understand that other people have mental states, which you have that ability, but here, you as a four year old, have failed to manage to keep track of Big Bird's mental state. Let's do a variation on this. So, here's a variation where you don't see that initial scene. Now you are asked to guess -- the candy is either here or here. Where do you think that the candy might be? Well, you say 50/50. Oh, I think the candy's in the drawer. OK, now Big Bird comes in and you're told well, you know, Big Bird thinks it's in the fridge. Where's Big Bird going to look? The answer now is, even if you're as young as three, that you say Big Bird's going to look in the fridge. Your guess isn't strong enough to overwrite your understanding of what's going on in Big Bird's head. This tells you something important. This tells you immediately that you're capable of understanding something about the contents of Big Bird's head. It's not a complete blank to you. Even younger than that, little kids can see somebody playing with a banana pretending it's a phone, right, and you ask does he know that it's not a phone? Yeah, yeah. The two year old will tell you, yeah, he's just pretending. And that you have the notion that somebody else could pretend to pretend something. So again, you can push this notion of being able to read minds back earlier if it gets simpler. And maybe this isn't really about the contents of Big Bird's mind it all.

Here's a cute version of the experiment done by Debbie [? Zicheck ?] once upon a time. Big Bird comes in, it's the original false belief game. big Bird comes in, puts the candy in the fridge, but this time Big Bird takes out his camera and he photographs it. He's got a picture of it. There's the candy in the fridge. Now, Big Bird goes out and Grover comes in, moves the candy to the drawer, you now know that the candy is in the drawer. Big Bird comes in, you are asked where's Big Bird going to look for the candy? Even though Big Bird has taken a picture of it, even though there's now a physical instantiation of the contents of Big Bird's mind, you still say it's in the drawer. You as a four year old are still unable to keep track of this. This suggests that maybe the problem is less with your ability to see into somebody else's mind, and more with something like the capacity of your working memory.

So, if you think about it this is very parallel to [? Lofta's ?] experiment I talked about either last time or the time before. You see somebody go through a yield sign. You later hear that it was a stop sign, and you believe, you come to have a false memory or a false belief, if you like, that it really was a stop sign, because we've managed to somehow overwrite your memory here. Maybe in this case what you're dealing with is not a qualitative change where you're seeing a change in the ability to see into somebody else's mind, but a big enough working memory that you can keep track of the task. So, another case where the development here waits on the development of another ability, a separate ability in this case, working memory.

OK, that's as good a place to stop as any.