5.3 Infant & Child Cognition

[0:0] We've been talking about a sort of biological turn in cognitive science over the last 30 or 40 years and in the previous discussion we focused on the applications of evolutionary theory to cognitive science. What we're going to talk about today, and again, we're just going to hit on some of the major themes and ideas of this area of study, is that branch of cognitive science that again it's not a new branch of study, that is to say, there were people studying these ideas in the mid-20th century, we'll see a famous cognitive psychologist, Jean Piaget a little bit later and much of his work was done before the advent of computers and before the heyday of cognitive science.

[1:06] But um, the sort of blending of the cognitive science approach and the study of infants and children has really blossomed again in the last quarter century, thirty years or so. So, we'll sort of look at some of the major results and some of the major ideas in child cognition, but of course as with of our discussion of the evolution in the previous time, we're only scratching the surface of the depth of the subject. First thing to say about studying infant and child cognition in human beings is that human beings are unusual animals from the standpoint of the length of their juvenile period.

[2:01] In fact, humans are born, by the standards of other primates, humans are born highly prematurely. The equivalent, for example, a newborn chimpanzee is pretty much, to the extent that you can make these comparisons, seems to be equivalent in development to a 9-month-old child or thereabouts. Human children are born in a highly, not only juvenile, but helpless state, compared to many other animals. Why is that true? Well, one of the major reasons is simply that the head size of human being infants is so large, even after 9 months gestation, that a longer gestation would simply be too dangerous to the survival of the mother.

[3:13] So a human child is born at the latest that it would be safe for the mother to give birth, but that means that the human infant is again rather premature by other animals' standards. There are terms in biology for these properties. Humans are referred to as altricial animals. Altricial meaning having slow developing, or a lengthy juvenile period. As opposed to precocial animals, which are quickly developing, mature at an early stage.

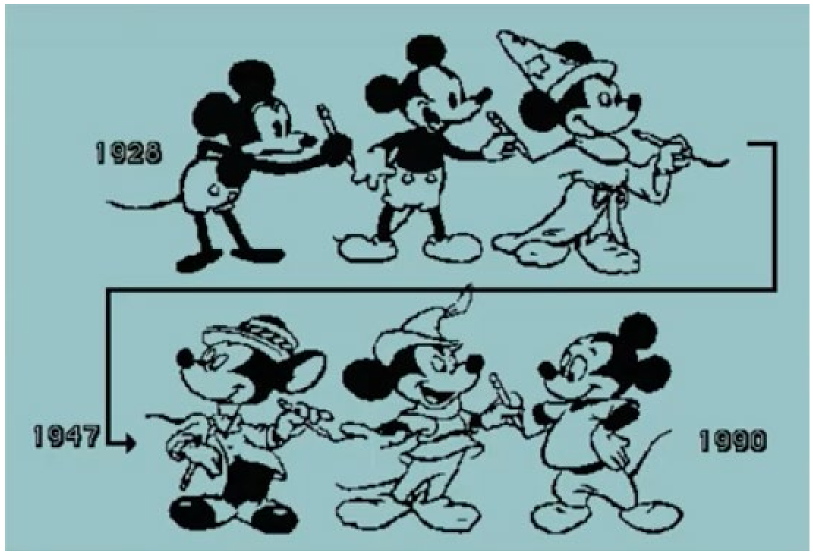
[4:04] To be a little more cautious, generally biologists don't talk about altricial and precocial animals, they talk about altricial and precocial traits of various animals. So, by some standards, horses might be altricial animals, for all I know, but the fact that they're able to walk on the day that they're born means that you could call them, as far as walking is concerned, precocial animals. Humans are largely altricial animals. We're born in a very helpless state, we have an extremely long period of juvenility and, which depending on, well there are various markers – when human children wean, get weaned, when they're able to walk, when they're able to participate in, you know, groups, when they're able to work in adult society, when they're off on their own.

[5:17] By many standards, people refer to the juvenile period in human beings as encompassing what we would call infancy, childhood, and more recently adolesce. So, depending on who one talks to, one could say that the human childhood extends to about the age of 20 or 21. Um, our main concern in this discussion is going be with infants and relatively younger children. But the fact of the matter is that human beings take a very long time developing. We spend a lot of time in our younger years assimilating the culture in which we're growing up, learning the language, learning the ways, you know, of the community in which we've been born, learning about physical objects, learning professional skills. These are aspects of human childhood that require an extended period of time. So, in some ways, we are the poster children for altricial animals.

[6:33] There are, by the way, I have on this slide, and I've been hiding behind this thing. I have on this slide a baby kangaroo. Marsupials also tend to be altricial. In fact, I often see these, they're born, baby kangaroos are born extremely helpless, like human infants, and they spend, baby kangaroos spend a long time in their mothers' pouch. I sometimes see photos of, you know, a child kangaroo hanging out in its mother's pouch and I'm thinking they should give the mother a break already and sort of leave that pouch and you know. They're just too old for this. But anyway, they're also altricial animals. Marsupials in general are altricial animals.

[7:29] One of the things about being altricial is that also places demands on the adults in the community. It's not just that, I mean, there are many animals – some reptiles, insects, fish – where the infants are born and, this is not all reptiles by the way, but there are many reptiles and insects and fish, where the child is born and the parents are gone. The parents just aren't around so the child is on his or her own and the responsibility for the parent ends with the conception of the child and that's it. Mammals are not like that, birds are not like that, and in the case of human beings, because we have such an extended period of childhood, this places large constraints on the adult population. The adult population has to devote attention for infants to feeding, caring for the infant, protecting the infant, then over time, teaching the infant and child.

[8:51] So adults are placed under, adult humans are placed under heavy constraints because of the altricial nature of human beings, and because of the relative helplessness of their children. One of the, sort of, you know, corollaries to that is that if you are altricial, if you're going to be born helpless and have an extended childhood, it really helps to be cute. Or interpreted as cute by the adult population. Human beings look at this picture of this baby and this baby kangaroo and we tend to get this, adult humans tend to feel this sort of protective urge toward creatures with juvenile characteristics. That makes sense, in other words this is something that for adults, it’s part of our biological equipment to be ready to protect and ready to take care of creatures, and particularly of course human beings, who exhibit juvenile characteristics.



[10:11] There was a really interesting essay by the evolutionary biologist [Stephen Jay Gould](), quite some years ago now, where he talked about the increasing juvenilization in the rendering of [Micky Mouse]() as a cartoon character. He showed this picture, this diagram, showing Mickey Mouse as he went from the 1920s up through about the 1990s. And the thing being, that if you look at the evolution of the way in which Mickey Mouse is drawn, I don’t know if this is entirely conscious on the animator’s part, but what they’re doing is giving him more and more juvenile features. His eyes are getting bigger, his head is getting larger relative to his body, his nose is getting less pronounced, his face is getting more squat, he’s a little chubbier by the end than he was at the beginning. So, this development is to make the animated character look more and more juvenile, look more and more like a child.

[11:25] It was, my belief is that to some extent this must have been conscious on the animator’s part in that they were trying to make Mickey Mouse more cute. Whether they interpreted that or whether they identified that as giving Mickey Mouse more juvenile features, I’m not as sure. Maybe it was kind of instinctual that they changed his look to look more juvenile. But this is an interesting case where the deliberate choices of the animators are exploiting the adult audience, um and I guess probably also children as audiences, but certainly the adult audiences to feel more warmly toward Mickey Mouse. At the beginning there he looks kind of like a mouse, or a rat actually, but by the end he doesn’t look anything like a mouse actually, but he looks more and more like a child.

[12:34] Why has there a been this blossoming interest in infant and child cognition? Now that we’ve sort of set the stage biologically, that humans have this prolonged childhood and relatively helpless infancy, and so there’s a great deal of mental and cognitive development that goes on over that time, why is there this blossoming interest now over the past quarter century or so? One thing is that it’s become much, much easier to study children than it was even 50 or 60 years ago. [Alison Gopnik](), the child cognitive psychologist, wrote at some point, and I think she’s right, that the advent of the video recorder, just the video tape recorder, was to the study of child cognition what the telescope was astronomy.

[13:38] Once we were able to videotape infant behavior, then we could carefully go over what infants were doing. Before there was an ability to cheaply and accessibly record, you know, just get an experimental record of what infants and children were doing, it was harder to study them. You could give them, you know, sort of tasks to do and watch them do them and take notes, but so much detail would be missed. So, the advent of video recording really had a huge influence on the study of childhood. There are also, from the cognitive standpoint, there are philosophical reasons why it might be interesting to study child cognition. We especially toward the beginning of the course, we sort of talked about cognition through the adult lens, talking about the tasks that adult thinkers have to accomplish: judgement, and puzzle solving, and so forth.

[14:53] And so those were tasks that were relatively tuned to adult performance and the models that were made were models of adult performance. And an increasingly convincing argument is that in order to really study, in order to understand adult cognition, in order to understand mature cognition, one has to understand it developmentally, one has to understand the stages by which we come to the expert or adult perspective. For adults who understand, for example, certain things about physics, or understand certain things about the biological world, what are the stages by which we come to understand those things? That developmental lens it tells us a great deal about what are the characteristics and potential limitations of the level of our adult understanding in these areas.

[16:04] And in this sense, I mention here the ambivalent legacy of the computational metaphor. We discussed somewhat earlier that the emphasis of many early AI projects (Artificial Intelligence projects) was to focus on what was considered to be highly intelligent behavior, very prominent early examples included things like interpreting chemical spectra, doing mathematical integration, playing chess. These are tasks that educated adults do. It turned out as people studied intelligence more and more that the most difficult things to model, the most difficult things to see a computational or algorithmic representation of were those things that we know how to do by the age of 5, like move around the room without bumping into things, or understand a simple story, or vision, which we spent some time on earlier before. Young children by the age of 3 or 4 or 5 are exhibiting the properties of, the kinds of properties of vision that are still challenging for computational models.

[17:30] So in this sense that computational metaphor might have held back in those early years a sort of more active study of infant and child cognition. These are the things that are changing over the course of the last quarter century or so. Now I've been talking about the last quarter century or so, the best known figure in children's cognition and studying children's cognition was the Swiss psychologist Jean Piaget who, he lived to a ripe old age, he lived into his 80s, but most of his work was done in the mid 20th century, and he really pioneered, you can really think of him as the sort of the grand theoretical of pioneer of the study of children's cognition. Piaget wrote a shelf full of books at least in the course of his lifetime. He was quite prolific. He's not easy to read. If you pick up books by Piaget, many of them are still in print, you'll find that they're not technically very difficult, but they're organizationally rather difficult. They almost read sometimes like lab notebooks where he's sort of taking notes on what children do in response to certain challenges and tasks.

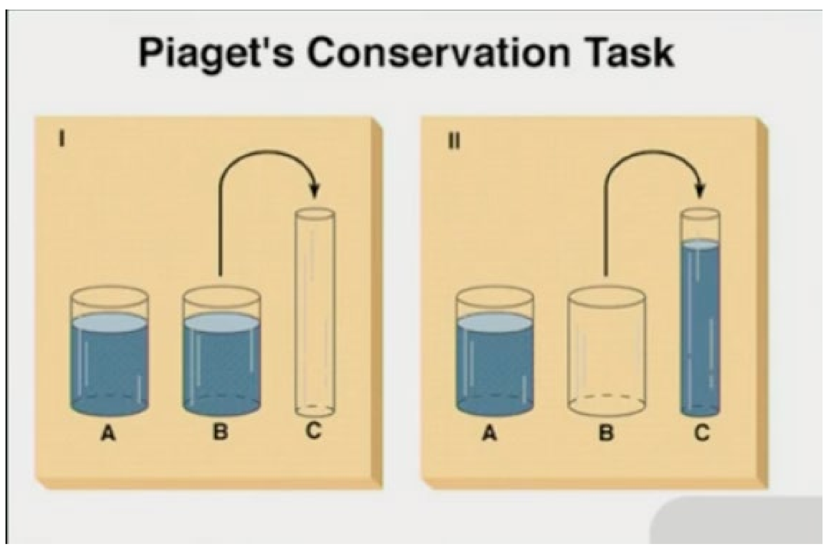
[19:08] So he's not easy to read. And his ideas developed over the course of a lifetime, but what I'm trying to do here is fit on one slide, if that's possible, sort of the basic foundation of the Piagetian account of children's cognition. First, and I have this up at the top, Piaget took a zoological approach to children. He was interested in human children from the species standpoint. He wasn't particularly interested in individual differences between children. So, he didn't care much and didn't write much about whether some children achieve certain cognitive milestones before others and what kinds of educational interventions could be done. In fact, he tended to think, it seems to come through in his writing, that the variation along that line was of secondary importance to the things that all human children share as members of the same species. So, he was really a biologist, you could think of him as a biologist first and a psychologist in the service of his study of biology.

[20:38] Piaget outlined, he basically broke down the development of children's cognition into stages and very often Piagetian theory is equated with a sort of stage theory of the development of children's thinking. The main stages that he identified, and again, first of all, I have three listed here: Sensori-motor Stage (< 18 months), Concrete Operational Stage (< 11 years), and Formal Operational Stage. In his writing, he subdivided these stages and expanded upon them and elaborated upon them, so there are many, many more substages and things like that. This is a very rough outline. But broadly speaking, the idea is that children up until about the age of a year and a half, are driven mainly by perception, immediate perception, and are not used to thinking in terms of the kinds of operations that they then begin to master as they move past the Sensori-motor Stage.

[21:54] The kinds of operations that I'm referring to mean things like taking the viewpoint of others or undoing a certain physical operation that one has done, or understanding the idea of abstract number. There were many sort of interesting features of young and infant behavior that Piaget identified that at the time he identified them were surprising actually, considering that people have lived with infants through all of human history, many of the things that Piaget noticed about the Sensori-motor Stage and about the Concrete Operational Stage were things that seemed puzzling to people in part because they had not really systematically studied children before that. The tasks and the themes that preoccupied Piaget throughout most of his work were things that would be related to what we would call mathematics, even higher mathematics, and physics. That is, he would observe how children regarded objects – are they permanent, are they solid, how do they move, and so forth. He was interested in how they were able to take different kinds of viewpoints on scenes or ideas. The early stage, the properties of the early stage Piaget called egocentrism, meaning children had a very difficult time understanding that what they were able to perceive was not what everybody was able to perceive, or even to identify the idea that other people might perceive things differently.

[24:07] So the egocentrism is a property of the Sensori-motor Stage and perhaps early Concrete Cperational Stage and so over time, as the Concrete Operational Stage proceeds, children are better able to do what Piaget called de-centering – adopting other points of view. He looked quite a bit at the kinds of mathematical operations that, if you've taken a course in group theory, you'll see that these are basic ideas of group theory: composition of operations, the reversibility of operations, the idea that operations might have an inverse, the idea of an identity operation. These were, of course the idea was not that young children would understand the symbolic representation of group theory, but whether they would understand some of the basic ideas that later get studied formally in group theory.

[25:10] Piaget was interested in how children understand numbers, how they understand sets. So, these were the focus of many of the experiments that Piaget did. He had this sort of grand theory of children moving between stages and substages according to processes that he called assimilation and accommodation. Very broad terms, roughly speaking, what he meant by accommodation was looking at new situations in ways that induced the child to rethink or change or move between one stage and another. So, accommodation is the influence, the experiential influences, accommodation is a response to experiential influences that cause one to rethink and move between one stage and another. Assimilation was more like the kind of thing that added experience to a particular stable stage at which a child was. In other words, if a child is at a particular stage in the Concrete Operation Stage, and he or she sees some new phenomenon that he or she can fit well into their stage of thinking, then that would be thought of as an example of assimilation.

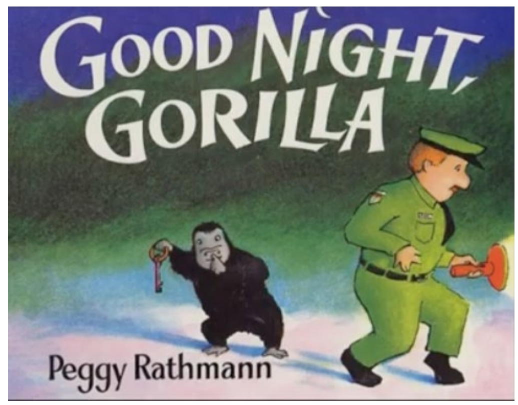


[27:02] And there were many, many sort of classic Piagetian experiments. All of this may seem very abstract. Let me give you an example of, there are many of these, but an example of a classic, well known Piagetian experiment that gives you a sense of the way that he would think about and examine children's cognition. Here's a situation where on the left you see that there are two identical glasses that are filled to the same level, A and B, with water. If you show those two glasses to a child of about the age of 5 or 6, and say which of these has more water in it, or could be perhaps which of these glasses would you prefer, but which of these glasses has more water in it, then children will say that they have the same amount of water, the two glasses are equal in that sense, they have the same amount of water. Now you take the contents of glass B and pour them into a tall cylinder. And then you have, you do this in front of the child. So now you're presenting the child with A and C the glass C and you've just done this pouring operation in front of them, and you say which of these has more water in it. And up to a certain age, children will reliably answer C, the cylinder has more water in it. There are a number of ways of thinking about this, but one way of thinking about it is that, what's a missing idea here. A missing idea for the child is this idea of the reversibility of operations. That is, the child has just seen the contents of B get poured into C, they could imagine therefore the contents of C getting poured back into B, so you're back where you were. So, the ability to reason about things like invertible operations should enable a child to say that the quantity of water has not changed.

[29:30] Up until a certain age, though, children will make this mistake. That's an interesting observation and it demands some explanation. What's missing in the child's cognitive understanding of physics or mathematical operations like reversibility that mean that he or she can't see that this would apply here. I should say that Piaget wrote these, he wrote extensively, and he pretty much founded in the 20th century what would be the modern study of children's cognition. But many of his ideas are no longer unchallenged. In particular, Piaget's ideas of coherent stages of movement between children's thought are widely challenged and I think it's fair to say that the consensus among those who study cognition in children is that children don't move that way in these coherent stages. What do I mean by coherent? They may still experience stages of thought about particular situations. Piaget felt that the stages were sort of broader than that. That when you, for example, brought into your intellectual quiver the idea of reversibility of operations, that that idea would then naturally spread to all kinds of other situations. In other words, the stages moved in this kind of intellectual progression as opposed to a task-based progression.

[31:19] I don't think too many people believe that anymore. But the crucial thing when talking about Piaget is not that he got all the right answers, but that he was asking interesting questions and making interesting observations about the things the children could or couldn't do. One of the most fascinating areas of children's development and thinking has to do with social reasoning. It's sometimes called the theory of other minds. I'll explain this particular picture in a moment but let me describe the – this is not a Piagetian experiment by the way – but it's an experiment in the Piagetian spirit, you could say. Let me describe this basic experiment that you could do if you know a maybe 4- or 5-year-old, you could do this experiment. It's harmless. But here's the idea. A child is brought into a lab setting and the child is shown a box labeled M&Ms. A M&Ms box. For simplicity, I'll make it a male child. So, he is asked, the child is asked what's in this box, do you think? And he says M&Ms. You open the box and show that inside the box labeled M&Ms is actually pencils. And the child is surprised. And the child, he goes, oh pencils, wow. And now you ask a crucial question, and you could do this in a variety of ways, you could have a puppet enter the room who hasn't been there, and you say if I ask the puppet what's in, I've now reclosed the box, if I ask the puppet what's in the box, what do you think he'll say? Or you could do it with a new person comes into the room and here's a new person and they haven't seen all the conversation that we've been having, the box is once more closed. If I ask this person, what's in the box, what do you think he'll say? And the child will say pencils. That's a little weird, right? I mean, person just came into the room, they didn't seen the conversation, they just see a box labelled M&Ms, why won't they make the mistake that the child just made?

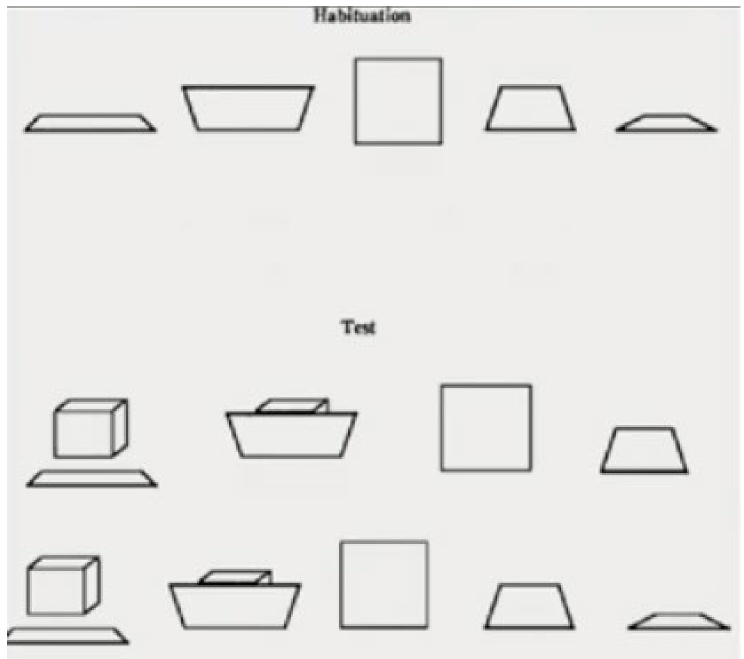
[34:08] Not only that, but what's even weirder is that the child now seems to believe that he always thought there were pencils in the box, what did you think before was in the box? Pencils. It's very odd. Past a certain age, when you do the same experiment with children, past the age of 6 or 7, and you say what will this person say is in the box, they'll look at you like you're crazy. You know, obviously this person is going to think there are M&Ms in the box. They think it's a trivial problem. Up until the age of about 5 or so, it's a puzzling problem and they don't see, again, touching on themes that Piaget did study earlier, the child doesn't seem to be able to reason from the point of view of another mind, that might have different ideas about a situation than they do. And that even extends to themselves, when they're asked to reason about how they thought about this box labeled M&Ms before, they just say I thought there were pencils in there.



[35:23] So there's a clear and interesting development of understanding other minds about this. Now what about this picture? When my son was 4, he loved this book called Goodnight Gorilla. I love the book. If you have a little kid, or you know a little kid, it's a great book to get, I'm sure it's still in print. It's a very funny book. This zookeeper goes around saying goodnight to the animals in the zoo and unbeknownst to him, this little gorilla has stolen his keys and is unlocking the cages for all the animals as the zookeeper is going around. Now my kid loved this story and he laughed at it, and he thought it was really funny. And knowing about this Other Minds experiment, when he was about 4, I asked him, look at the cover here, it's made very clear even from the cover that the gorilla has the zookeeper's keys and don't tell the zookeeper. I am the only one who knows I have the keys, and you do too, looking at the picture, but the zookeeper doesn't know. Anyway, I asked my kid does the zookeeper know that the gorilla has his keys? And my 4-year-old son said yes. And I was thinking how could, not only that's so interesting that he believed that, but if he believed that, why did he like the story so much? Since it seemed to me that the story was based on the whole idea that the zookeeper didn't know. So, these are puzzles. But this theory of minds is one of the things that's most actively studied in children's cognition.

[37:25] Finally I should mention a line of work that has to do with infants' understanding of the basic physics of objects. A very famous Piaget study on object permanence had to do with, I'm kind of waving my hands at the exact parameters of the experiment, but something like for an infant say under 6 months old, you present the infant nearby with a favorite toy and the infant will reach out and sort of bring the toy toward him or herself. And also under other circumstances, you show that if there's a blanket someplace that the infant can lift the blanket. So, we know that the infant likes this toy and will bring the toy toward himself, and we know that the infant can lift the blanket. Now you take the toy, this favorite toy, and in full view of the infant, put it under the blanket. All that's now required if the infant wants the toy is to lift the blanket and pull the toy toward himself. We know that they're able to do both those things.

But they don't do it. To Piaget they sort of behave as if the object isn't there. And this was again one of the tenets of egocentrism to Piaget, that if you can't see an object, it must be gone. Things do seem to be more complex than that, however, and in more recent studies, and by more recent I mean over the past few decades, there've been quite a few studies involving infants' understanding of objects. So let me show you just the diagram of one of these studies. Here's the idea.



[39:25] You place an infant… These are, I haven't actually done these experiments, but I'm told that they're not always the easiest things to do because you're dealing with 4- or 5-month-old infants, very young kids, and they're not always that focused and sometimes they get fussy, and you know. So, the version of the story I'm telling is a somewhat abstract and cleaned up version of the story. You place the child at a lab table. And then this top row is showing a sort of board or screen that can be brought up and then lowered backward. So, you can take this screen and bring it up or lower it backward all the way to the table. And what you're seeing in that drawing is showing the screen on the table and then being brought up and… I should do it this way. On the table and then being brought up and then here's the screen full view, and then bringing it back and bringing it onto the table. Now, the infant gets used to that. You do that enough and basically what you're measuring is how long the infant looks at these situations. So once the infant gets used to this little motion that you've been doing, they get a little bored and they're not looking at it that cautiously anymore. Now you take an object like this block in this second row here and you have the screen in front of the block, you bring up the screen and you lean it down and it bumps into the block. Children note that. Ok so you take the screen, bring it up, and it bumps into the block. Now you try another version of the experiment, it's kind of a magic trick, where the block can be moved away, you know, moved under the table, outside of the infant's sight.

[41:36] So you bring the screen up in front of the block, move it, and then move it all the way down to the table. The block has disappeared. It's a very simple kind of magic trick to play with an infant. And they look a great deal of time, they look interested. They spend much more time looking at that third situation than they did with the second situation. The natural interpretation, these are pre-linguistic children you can't ask them what they're thinking, but there seems to be at least a clear indication that they're surprised that the screen was able to move all the way back down to the table. What happened to the object behind it? That sort of contradicts the egocentrism idea of the object permanence experiment. After all, if infants are confused by this third scenario, it would be because they expect the screen to bump into the block, they expect there to be evidence of a block behind the screen. I'm going back to the previous slide now. Those types of experiments, in which people measure looking time or sometimes children are just given a nipple on which to suck on a baby bottle and then the measures are how much time or how vigorously they suck the baby bottle. There are only certain things you can measurably get an infant to do to register surprise. But there are other sorts of experiments dealing with this same notion of how infants think about objects.

[43:25] For example, if you have a screen put up and you take a doll and put it behind the screen and you pull the screen away and there's one doll sitting there, the infant is not terribly surprised. If you show an empty table, you put the screen up, you put a doll behind there and you take a second doll and put it behind the screen, and then move the screen down and there's only one doll behind the screen, the infant looks surprised. Does that mean that infants count? Well, the usual term that people use in both infant and animal cognition is a sort of pre-counting skill called subitizing, which applies generally to only very small numbers of objects, perhaps up to 3-4 objects. Or sometimes it's used that people can distinguish between say an object and ten objects. Even if an animal or an infant can't count to 50, they know that this quantity of 50 objects is much greater than the quantity of 10 objects.

[44:44] So it does seem that the ability to do subitizing. How closely that matches to later mathematical ability is an interesting question and one that's currently being studied. If you have an object like a truck that moves behind the screen and then reappears at the other end of the screen, children don't find that surprising. A little toy red truck moves behind the screen, they can't see it for a couple of seconds, and then it reappears out the other end. They're not surprised. If the truck rolls behind the screen and then doesn't reappear, they're surprised. One of the interesting things is if the truck – I think this is true, at least it was the last time I read about this – if you have a red truck that moves behind the screen and a yellow truck that emerges from the other side of the screen, children don't seem surprised. So, the idea that a red truck will continue on and continue moving, that seems to be part of an infant's equipment about understanding the physical world.

[46:15] Apparently, they don't worry too much about whether an object might change color while it's out of sight. That's an interesting division. There are many experiments in which infants will look at one object bumping into another and causing motion and, that they understand that one object is the cause of motion of another, sometimes these experiments have been done in such a way that the objects are given kind of personalities, they're sort of anthropomorphized so that one object is seen to be sort of blocking another deliberately or pushing another violently, and children seem to be able to, infants seem to be able to interpret scenarios along those lines. Also, I should mention an experiment in which, if you have a dark room, and you give a baby, an infant a ball to feel, a beach ball or something like that. They're able to feel this ball but not to see it. And later you turn on the lights and the infant is presented with, and they haven't seen this ball, they've only felt it. You turn on the lights and the infant is presented with both a cube and a ball, the infant will spend more time looking at the ball. So, it seems that they have a link between their tactile perception and visual perception. All of these are sort of clusters of experiments. Many of them are still much debated and admittedly the interpretation of these experiments has to be based on the perhaps relatively slender evidence of apparent interest, sucking time, looking time, things like that. But… there's still debates about the interpretation of many of these experiments, but it does seem that they indicate that infants have a much richer knowledge of the physical world than they'd were given credit for being, certainly by Piaget and certainly by people before that.

[48:50] There's a famous quote from the philosopher William James who described the infant's world as "a blooming buzzing confusion…" it's an oft repeated quote. Well, in many ways it probably is a blooming buzzing confusion, but apparently infants are born with, or acquire extraordinarily early, most likely are born with, you know these are things that are naturally acquired under almost any circumstances, that infants do have some knowledge at a very early age about the natural behavior of objects.