ALIA MARTIN: I'm going to be talking today about how infants and kids start to develop an understanding of communication and why this is an important topic for understanding human intelligence. So what is communication? So really, basically, communication is a transfer or exchange of information. And importantly, in human communication, this isn't just any kind of information, but it's specifically the kind of information that's in our heads and in our minds.

So for example, there's information in my head right now that I'm going to be transferring to you over the course of this talk. And the reason we need communication to do this and that we use it all the time is obviously that everyone has minds of their own and that we don't have access to the mental states of others. And we can't automatically transfer our own mental states to theirs without some means of making those mental states observable in the form of communicating with them.

So people are both cognitive beings-- we have to sort of navigate the thoughts in our heads and try to figure out the thoughts that are in other's heads-- but we're also social beings. We really benefit from gaining access to the thoughts in the minds of others and giving them access to our own thoughts. So for example, for cooperation, competition, learning, and teaching, and all the kinds of social interactions we do with each other, we have to be able to share the contents of our mental states.

And it's this sort of joint, both cognitive and social nature of communication that I think makes it especially important for understanding the development of human intelligence. It sort of crosscuts a lot of these core knowledge domains that Liz talked about in her talk. So human communication requires reasoning about others' cognitive states, so understanding what others' beliefs, and desires, and intentions are. It also requires reasoning about social interaction, so understanding that typically these kinds of thoughts, and beliefs, and intentions are not shared among different people.

Everyone has their own that are unobservable and housed in their own heads. But in the

context of a particular kind of social interaction, these people can intentionally share their thoughts with each other. And communication often involves reasoning about a third thing, which is language or communicative signals outside of language as well. And so I'm going to back to this point at the end, but all these types of reasoning are going to come up in the studies about infant communication that I describe in the talk.

And so Liz talked about how infants start out with these coherent, separate, principle, and core knowledge systems that contain some limited representations for reasoning about the world, and which kind of come together around the end of the first year. So if we want to figure out how to build a model of how social cognitive development works, we're going to need to understand how an infant starts to figure out, using the core knowledge that they have early in life, the components of communication and also how these components come together so that infants can build a more complex causal model of communication like adults have.

So this is just to illustrate the points I'm making about the communicative situation. So in any given communicative situation, we can't just think about the words that are being said or what we're hearing. We need to think about it in this broader context of having a communicator or maybe multiple communicators, an addressee or an audience, and also the things that the communicator is saying in the broader context that allow us to figure out what's going on in this social interaction. So it really requires understanding that the communicator's mental states are being transferred in this causal way to the mind of the addressee.

So I'm going to structure the talk in terms of some important insights from the philosophy of human language and communication that I think have really guided the way researchers in the last, say, 50 years have been thinking about the development of human communication as well. So I'm going to broadly illustrate the three points that I'm taking from each, and then I'll expand on them in each section.

So the first insight that I think is really important for understanding how we think about communication comes from John Austin, who brought up the important point. So before Austin, people tended to think about language or study language a lot in terms of language itself, and the semantics, and syntax, and just the language signal. But Austin pointed out that language is actually not just about the content, but it's also an action. It's actually something that we use, and we do things with it, in the same way that we do things and accomplish things in the world using other kinds of actions that we engage in. So Austin sort of brought up this important distinction that language is not just about the content.

So to illustrate with an example, in this communicative interaction, there's language here. This person is saying, is there any salt? And Austin analyzed this in terms of not only what the words meant, but in terms of three layers of intentionality. So in this simple interaction, he pointed out that there's a locutionary act, or the meaning of the sentence, which is that there's a question being asked about the presence of salt. But that there's actually something else going on here as well, which is that there's an illocutionary action, which is what he considers to be the intention underlying the action, which is to request the salt.

So if you actually just read this sentence, it's kind of under-determined. It's not necessarily obvious that this person's asking the other person at this table to pass the salt. But if you take it within the broader context of the interaction, you can understand that what's really going on here is not just a sentence being produced, but rather one individual requesting something from another, who is then supposed to understand the request, and in the third layer of analysis, cause the addressee to provide the salt. So the idea is that there are these multiple things going on in the context of a communicative interaction involving language that go beyond the words that are actually being spoken here.

And so if you're an infant, just like in philosophy of language, the focus in infant cognitive development-- also for a long time, and still is, we still need to understand these things-- was on understanding how infants learn words, or how infants figure out the meaning of language, and how it relates to objects in the environment, and later, to the abstract concepts that language indicates. But importantly, understanding communication for an infant is going to be more than about just figuring out the meaning of these words. And so following the philosophical tradition of people like Austin, who introduced the study of pragmatics to language, developmental psychologists as well started thinking about the importance of recognizing communication as this broader action in its context for understanding how infants come to be good communicators themselves.

So if communication involves this whole context of action and interaction between people, if you're a baby who's in the business of understanding the social world, the agent world, and the world of language, you're going to be well-served by developing an ability to identify these kinds of communicative actions or situations and their components, and to begin to understand how they work. So how do infants start to figure out when communication is going on in the world around them, rather than just identifying words and associating them with objects?

So actually, there's a lot of evidence that infants are identifying key features of communicative situations really early in life. So from the time they're born, newborn human infants prefer listening to speech over other sounds. So the typical method that's used to measure the preference of an infant who's only one to four days old is to have them suck on a pacifier that's connected to a machine that detects how strongly infants are sucking. And then the sucking is used as a measure of infants arousal upon hearing a particular sound or being exposed to a particular stimulus.

And so what researchers found is that if you have infants suck on this pacifier while listening to speech sounds and nonspeech sounds in alternation, nonspeech sounds being sine wave-produced sounds that are very similar to speech in their features. If you listen to it, it has the prosodic contours of speech and sounds a lot like it, but it's not actually speech. You can't actually parse any words from it. Infants showed a preference for listening to speech over nonspeech, or more arousal when they listened to speech. So they maintained their arousal for speech over the course of the experiment, but for nonspeech, it declined. And so extremely early in life, infants seem to have this bias for paying attention to the primary communicative signal of our species, that is, human speech.

Quite early in life as well, infants recognize some of the important features of the social context surrounding speech, so getting more into the domain of the important features for communication. So by six months, infants seem to recognize that speech is human-produced, or at least associate speech with other humans, and also human-directed.

So in one study, infants saw pictures of human faces or faces of monkeys, and they heard different sounds. So they either heard-- oh, it seems like the sound is not on, but that's OK. So they either-- oops. So they either heard a speech sound in a language they never heard before repeating itself, or they heard a monkey call. And infants in one trial either saw-- so in the first trial, say, they'd see the human face, and then they could listen repeatedly to a speech sound until they looked away for two seconds. And then they would see a monkey face, and then they would hear either a speech sound or a monkey sound and be able to look at this image while listening to that sound until they looked away for two seconds.

And so they got all possible combinations. Sometimes they saw a human face and listened to speech. Sometimes they saw a human face and listened to the monkey sounds. And sometimes they saw the monkey face and listened to either human speech or the monkey

sound. And the question was whether infants actually could match speech sounds to humans and recognize that they should be produced by the human rather than the monkey. And that's what they found. So you can see that when infants heard speech, they were much more likely to look at the-- yeah, they were looking at the human when they heard speech, and then they were looking at the monkey when they heard the monkey calls.

Similarly, infants seem to understand by six months that speech is directed at other humans. So when they saw a person talking behind a barrier versus acting, so swiping with her hand behind a barrier, and then the barrier was revealed to reveal either a person or an object, infants looked longer for the speaking familiarization when they saw that there had been an object behind the barrier than a person, suggesting that they expected speech to be directed toward another person. And in contrast, when they saw the person swiping, they looked much longer when they saw a person behind the barrier because typically, we don't swipe at people. We tend to speak to them.

So this suggests that infants understand some of the features of the context in which human communication is produced. Importantly, infants do still seem to be developing this ability over the first year of life because it's not until 10 months that they expect mutual gaze between speakers, which tends to be an important part of understanding the social context of communication.

So in this study, infants saw two people facing each other. This is just one of the experiments from the study. But you can see that they saw the two people looking at each other and speaking to each other, or the two people looking apart and speaking to each other. Infants at nine months didn't differentiate between these at all. So at nine months, they didn't necessarily think that the people were going to look at each other when they were speaking. But at 10 months, you can see here that infants looked longer for the averted gaze than for the mutual gaze.

So infants seem to be able to recognize when a communicative context is going on early in life. But we don't necessarily know from these studies whether they really understand that communication is happening or whether they're just detecting some important features of communicative interactions that might help them to glom onto communication so that they can eventually develop an ability to figure out what's going on within the communicative interaction themselves. So, so far in the studies that I've mentioned, there's nothing cognitive here. There's nothing really about infants having to understand the intentions or the mental states of

the speaker going into the mind of the addressee, like I was talking about before.

So a question I've explored in my research is whether infants recognize that when these features are in place, when you have a communicative signal, which is something they recognize, when you have a communicator and addressee who are socially engaged with each other, do infants recognize that communication can actually lead to the transfer of information? So do infants understand that speech, using speech, because this is something that infants seem to recognize as a signal that's important in communicative context, can transfer information between individuals?

So we can use speech to communicate with each other about what we're interested in. So if I'm observing this interaction between a communicator and an addressee, I can infer that if the communicator says, the cup, and there's only one cup present, the addressee's probably going to be able to figure out what it is that the communicator wants. And I can figure this out even from a third party perspective. And I can also understand that other kinds of sounds, like perhaps a positive emotional vocalization, are not going to be as effective in communicating to the addressee what the communicator is interested in.

So speech and also other communicative signals as well that can specify this sort of information, perhaps like pointing or particular kinds of gestures, can transfer information from one individual to another. So speech is going to be more effective for communicating than other kinds of noncommunicative actions. And importantly, for the purposes of this study, you're not just going to know that communicative information transfer is going on because you know what the word cup means, even in a situation where you're listening to a foreign language, and you have no idea what the meaning of the words are. Even in this situation, you're going to understand that some kind of communicative information transfer can happen. So we've all had the experience of being in a foreign country, presumably, where you're listening to people speak to each other. You can't necessarily understand what they're saying, but you know that information transfer is happening.

So the interesting thing about communicative actions like speech is that when we witness them, we can know that people are communicatively sharing information, even when we don't know what information is being communicated ourselves. And this insight suggests that maybe, if you're an infant, one really good way to jump into the communicative interactions around you and start to understand what's going on is to be able to identify when others are communicating. And hearing the sounds of speech exchanged between two people in the

context of a social interaction might be a really good way to do this. So an ability to figure out when communication's going on like this might provide infants with this really powerful way of being able to track the information flow between two other people's minds and also to figure out, based on their responses to each other, what the actual content of the words might mean.

So we asked whether infants recognize that speech is communicative at 12 months of age. And so in the procedure of this study, infants were privy to a third party interaction between a communicator and an addressee. And the infant is always just observing the interaction. This is so that we can isolate whether infants think that certain communicative vocalizations can transfer information from the communicator to an addressee, even when the infant themselves has all the information. So the third party nature of this procedure is important here for seeing whether infants really are thinking about the fact that thoughts are typically isolated in particular people's minds, but with communication, they can be shared.

So infants in these studies were given a violation of expectation paradigm. In this kind of experiment, as many of you probably know, infants are shown a story through a series of scenes. And then in the last scene or series of scenes, they're shown different kinds of endings. And we're interested in whether infants are surprised or look longer at some endings more than they do at others.

So infants in these studies were shown a live display where they had an actor in front of them in a stage. First, they were familiarized with this actor showing a preference for an object by picking it up and playing with it repeatedly in three separate scenes. And so, as in the studies by Amanda Woodward that Liz already mentioned, infants, by 12 months and as early as three months, will attribute a goal to this person for reaching for that particular target object.

So after being familiarized to this, infants saw an addressee, who was a new person, present in a totally different part of the stage. They had never seen this person before, and they'd never seen the two people together before. This person reached for both objects in turn. So first, she grabbed this one, then this one, and then this one, and then this one again to show that she didn't have a preference between the objects and could reach both of them.

Then in the test scene, so this is the ending that we showed infants, they saw the two people together for the first time, but now the communicator couldn't reach the objects because only her face had access to the stage. But the addressee could still reach them just fine. At this point, the crucial manipulation was the vocalization uttered by the communicator. So she either

produced a speech sound, the nonsense word koba, which infants had not heard before, she produced a coughing sound, so something that would typically be physiological and not intentional or communicative in any way, or an emotional vocalization, so a sound that perhaps could convey information. If I say, ooh, you might think I'm interested in something, I'm feeling positive, but you won't necessarily know what it is. So this one's sort of in the middle of the other two.

And then, infants saw the addressee either provide the target object that the communicator had reached for before or the nontarget object. And the question is, do infants understand that speech as a communicative signal, do they have some expectation that even though they've never heard this particular speech sound used before, that speech can transfer information such that the addressee will now be able to select the correct object? Whereas nonspeech vocalizations like coughing and emotional vocalizations can't. So if so, infants in the speech condition should look longer to nontarget than target actions, responses, finding these unexpected. And infants in the other two conditions shouldn't differentiate between the two.

And this is what we found. So in the speech condition, infants are looking longer to nontarget than target, suggesting that they understand that speech can transfer information about the communicator's goal. But when the communicator coughs or produces an emotional vocalization, infants don't show these same expectations. So this is some initial evidence that by 12 months, infants not only recognize the context in which communication occurs and attend to speech as a special signal for communication, but they also understand that speech is something that's able to transfer information between two people.

So we also ran a few control conditions to rule out alternative explanations for this. So one important question is, are infants really reasoning about the addressee's access to information in this situation? So for example, in the case where the-- if infants are really reasoning with the addressee's access to information, then in a case where the communicator makes a positive emotional vocalization, and the addressee has previous information about what she's interested in, so for example, if she just saw that the communicator was trying to feed her child or wanted a drink of water, she might know now that a positive emotional vocalization is indicating something like the cup.

So we set up a scenario like this as well. In this case, it's exactly the same as the previous study, except that the addressee had visual access to the communicators preference during the familiarization phase. So now she knows what it is that the communicator likes. And this is

important for making sure the infants recognize that something like visual access can provide the addressee with information about the communicator's interest. So now infants saw the same addressee familiarization. And then in the test, they saw the communicator produce the vocalization ooh once again.

So now even though ooh was not treated as a communicative vocalization in the previous studies, if infants are reasoning about the kinds of information that the addressee has access to, they should now expect that the addressee will provide the target object because she knows from a previous scene what the communicator was interested in. So this is important also for ruling out the possibility that maybe just hearing these noncommunicative vocalizations surprises or confuses infants or makes them unable to reason about the scenario anymore. Here, they're getting a noncommunicative vocalization, but the addressee has access to information.

And here, as in the speech condition, infants looked longer at the nontarget outcome. So this is just some evidence that infants are really thinking about the idea that relevant sources of information, such as a communicative vocalization, but also prior visual access, can give the addressee information about the communicator's goal. So they are reasoning about information access.

Another important question is, are they really thinking about the source of information, or do they have-- so what's really the mechanism behind what infants are doing here? Are they thinking something like, when I hear speech, everything will go well, or the speaker is going to get what she wants? Or are they really thinking about communication in this causal way, where the information has to come from the speaker and be delivered to the listener in order for it to work?

So to test for this, infants saw another communicator familiarization. Here, the communicator is alone, so they've never seen the two people together before. She reaches for the target object. Then they see the addressee again. And then in the test scene, in this case, the addressee is the one who produces the speech. So speech is present in the scene as it was before, but it's not being produced by the communicator or the person who showed a preference.

So if infants just think that speech leads to people obtaining their goals or magical outcomes happening, then they should expect the addressee to provide the target here as well. But if

they understand that they don't know anything about the addressee, in which case, this is not really informative about either object, then they should look equally to both outcomes.

And in fact, this is what they do at 12 months. So infants here don't expect information to be transferred from one person to another, unless the first person who communicated is the one who actually had the information to provide. So by 12 months, infants seem to recognize that speech is communicative, and they seem to have some of the parts of a causal model of communication. They're not just thinking about speech as something that can produce successful outcomes, but as something that can be used to have information move from the mind of one individual to another.

So a 12-month-old seemed to recognize that speech is communicative. But we really wanted to get at the idea that understanding that speech is communicative might be something that drives and guides word learning and language acquisition, rather than something that is as a result. So what a 12-month-old could be doing in this study is hearing the word koba, associating it with the object that the communicator had reached for, and then thinking, OK, that one's the koba, so that's what the addressee should reach for. But in these studies, we were interested in whether infants at an even younger age, who would be very, very unlikely to be associating the word with the object or learning a label for the object over the course of the study, would also recognize that speech can transfer information about one person to another person.

And so for this reason, we tested 6-month-olds, because 6-month-olds understand only some very, very common words in their environment and will look to the right object when they hear the label for it. But these are very, very limited words, and there's no evidence for learning a word in a single trial, which is what they would have to do in this study. They would have to hear koba, and then think back to what the communicator had reached for, and really learn that word over the course of the study, which we have no evidence that a 6-month-old can do. So the goal of looking at this age group was to see whether infants might have a more abstract understanding of the idea that when speech is produced, information can be transferred from one person to another, even when they themselves don't know what that information-- or what the link between the word and the object.

So a 6-month-old saw the same scenes. We gave them the speech versus cough contrast. And they look the same as the 12-month-olds here. So you can see that in the speech case, they're looking longer for the nontarget outcome. And in the cough case, they're looking longer

for the target outcome. And so we haven't done all of the same control conditions as with the 12-month-olds here. So I think there's a lot of room for questions about how a 6-month-old's understanding of communication in this causal way more limited than the understanding of 12-month-olds. Would a six-month-old think that if speech was produced by a loudspeaker or by the addressee, that the communicator would still get the right object? So there are a lot of open questions about-- these basic questions about how infants' understanding of communicative information transfer starts out.

So these experiments suggest that by six months, infants seem to understand that speech is communicative, in addition to the other studies that suggest they understand some of the features of communicative interactions. They recognize that it transfers information from one person to another. And I'd like to argue that this might be something that provides a mechanism for language and knowledge acquisition, so sort of guides infants to the kinds of relevant interactions where they might want to learn things about people, and their mental states, and the words that they're using, rather than first learning those words through association and then later coming to this more abstract understanding. So the idea is that infants might start out with this understanding of what communication is and when it's happening, and then can sort of fill in the rest from there, and that this might be one of the earlier blocks of that.

So I'll try to go fairly quickly through the rest. So the second insight I wanted to bring up that I think is especially important is that communication requires this focus on intentions. And this was really the work of Grice that highlighted this, and in particular, a special type of communicative intention. So going back to the example from the beginning. When someone asks, is there any salt, Austin proposed that there are these three levels on which we can think about this communicative action. And Grice was the one who really formalized this by talking about this special kind of intention that we see in the domain of communication, human communication in particular, which is the idea of speaker meaning.

And so his idea is that there's this double-layered intention that comes when we're communicating with each other. So we have a communicator who intends the addressee to respond in a particular way. So here, the communicator wants the addressee to provide some salt. The communicator intends for the addressee to recognize that the communicator intends to have that response. So this person not only wants this person to pass the salt, but wants her to recognize that that is what he's asking for, that that is the request that he's making.

And importantly, this third point, which is that the communicator intends the addressee to respond that way on the basis of the recognition of that intention. And so to make this a little more concrete, in this case, if he asks her for the salt, and she passes it because she heard him and understands that's what he's asking for, that's great. But the argument is that communication wouldn't really be happening if, for example, she was wearing headphones and listening to music, and she hadn't really been listening to him, and she just happened to pick up the salt and pass it to him.

So communication, I mean, it would look like a communicative interaction. The right kind of outcome is still happening in response to what he said. But if she has no access to the actual message, if she doesn't produce the response by virtue of understanding what the communicator is trying to say, then communication hasn't really occurred. It's just sort of a lucky accident.

So I'll skip this part. So this is this important kind of intention that we see in human communication, in which I'll later briefly mention, we don't really see in animal communication in the same sort of way. So how do infants start to get this idea about communication, that it's not just about identifying communicative interactions, but also about understanding these particular kinds of intentions?

So in the '90s, there was this shift in developmental psychology to looking at word learning, not only in terms of infants' associations of words in the environment, but to also, with the work of Dare Baldwin, to thinking about other people's intentions when they're using words. And so she had these really elegant studies where-- with this funny image-- where she pointed out that if infants really were learning words through association, then it wouldn't be very efficient for them because they would make a lot of mistakes.

So for example, in this kind of situation, here's a dad and his baby. The baby is looking at this lizard. The dad is looking at this rooster. And the dad says, what a cheeky rooster. So if you as the infant are only learning words on the basis of associating what you hear with what you see, you're going to learn that the word rooster refers to this thing rather than to this thing. And you're going to get it wrong.

So Baldwin did a whole host of studies in the second year of life where she set up situations where infants were looking at particular objects like here. And then she had their parents or an experimenter look at a different object and label that one to see what infants would do. And

what she found is that infants actually would consult their parent or consult the other person for cues to reference, to what they're intending to label. So if, for example, in this situation, the infant, when hearing this, instead of just assuming the word refers to what they're looking at, would actually look up to dad to see what he's looking at and then follow his line of gaze to understand that this is the object that he's actually talking about.

AUDIENCE: At this age? At this age?

ALIA MARTIN: Yeah, at this age. Yeah. So the idea is that infants in the second year of life, at least, are understanding that understanding what someone's referring to involves consulting cues to their attention and intentions rather than just the infant's own.

And I think I'll skip this one. There are other studies showing this, too. So in this one, there's an experimenter who puts these two objects in a box. The objects switch while she's absent. And then she looks in one box and says-- the boxes are closed, and she says, there's a sefo in here. So if the infant understands that they have to pay attention to what the person knows about or what the person thinks rather than their own knowledge to figure out what she's labeling, then now when she says, can you get the sefo, the infant should actually pull the object out of here, assuming that this is the one she's labeling, because that's the one that she was intending to label.

And in fact, that's what infants do at 17 months. In the case where the experimenter had a false belief about the location of the object, infants tend to go to the non-referred box more often because they think that that's the one that she's labeling. But in the case where she saw the switch happen, so now she knows what's everywhere, infants will just go to the box that she's referring to figure out the location of the object that she's naming. So this is all in the second year of life, not those younger core knowledge ages that Liz was talking about.

So this is evidence that infants consult speaker cues to intentions, but not of this special kind of intention that Grice was pointing out. So I'm just going to tell you about a couple-- well, one of my favorite studies, I just think that this is really neat-- where Ellen Markman's lab and then later replicated by Tomasello's lab, showed that it seems like children, by 30 months and then gotten down to 18 months by Grosse et al, actually do seem to care about not only the effects of communication, but also that the effects are produced by virtue of the message being understood.

So you're probably wondering why there's a dirty sock on the screen. So in this study, children

were presented with two objects. So they saw, on a table, there were two objects that were out of their reach, a truck and a dirty sock. And the idea was to elicit children to request an object. Now obviously, the children are going to request this object, which is what the researchers had intended in this case. So children tended to point at this object. So they had children producing their own communication, and then the experimenter responded to the communication of the infant in one of four different ways.

So she either said, you asked for the truck? I'm going to give you the truck. So she expressed understanding of the request, and she provided the requested object. In a second case, she said, you asked for the truck? I'm going to give you the sock. So here, she expressed understanding, but refused to commit to the request, to give the thing the child had asked for. In a third case, the experimenter said, you asked for the sock? I'm going to give you the truck. So this is kind of a strange pragmatic situation where the experimenter actually gave the child the object they wanted, but she expressed a misunderstanding of the child's request. And this is the crucial case here.

So the question is, obviously, in the case where the experimenter provides the thing and expresses understanding, children should be quite happy. And in this situation, they probably shouldn't be very happy. And what the experimenters measured was the amount of times that the child repeated the label of the object that they had asked for. And they also measured other behaviors as well. It's this situation that's important for understanding what kids care about in the context of this communicative interaction. So the question is, are infants perfectly happy here to take the truck and not complain because they got what they wanted? Or do they care about the experimenter giving them what they wanted because their communicated message had the proper effect on the addressee?

And what they find is that when the correct object is provided, and the experimenter does not express understanding of the request, infants actually showed the most repetitions of the name of the requested object in this case. The researchers concluded from this that infants don't just care about getting what they want or using communication as a sort of instrumental means of getting people to act in certain ways, but rather as an intention to have their messages understood and delivered to the other person. So they care about the impact of their communicative signals on the understanding of the addressee, not just on the response of the addressee, which is sort of like the idea that Grice was talking about with speaker meaning.

Similarly, when children are responding to other people's requests, they also care about this. So this is a study that I did in graduate school. It's sort of the opposite of the previous study, or the inverse. So we had an experimenter requesting from the child specific objects for doing specific tasks. This is 3-year-olds. So she would request something like a cup to pour a cup of water. The child had previous information from playing games with the objects with another experimenter that one of the cups was perfectly fine, and one of the cups was broken and had a big hole in the bottom.

And so when the experimenter asked for a cup, the child could either give the cup the experimenter asked for, which was sometimes the perfectly good cup, or sometimes the experimenter requested the broken cup. And the question was, do children pay attention to the fit between the task and what the experimenter wanted when they're responding to her request? And what we found is that children were much more likely to give the requested object when the experimenter had requested a functional object than when she'd requested a dysfunctional object. So if I say, I need to pour a cup of water, can you give me that cup, and the cup is broken, children tended to go and get a better cup instead of the one that I had requested.

Interestingly, though, even though children did this, it didn't seem to be enough for them to give the experimenter something good that she wanted. This is a graph of the comments that children made about the function of the objects depending on the kind of request that was made. And what you can see is that when a dysfunctional object was requested, when children tended to provide the functional object instead and not respond to the request, they were much more likely to try to explain their behavior to the experimenter and acknowledge what it was the experiment had originally wanted. So it seems like children in their own behavior, by at least three, which is a little older than the other studies, acknowledge what the speaker meant to ask for and explain while they're doing something else, even when they're not responding to that thing.

And so, just briefly, in the last section, I'll talk about a third insight about communication that I think is really important, which comes from Clark, which is that communication is this joint action of accumulating common ground. And so in an example of an adult study about this, they showed adults pictures like this one of New York City, and they had people play this game in pairs. They had people who knew about New York City who were experts and who lived there, and then they had other people who didn't know anything about New York City.

And they gave them a bunch of pictures. They told them that their goal was to-- the person who was the addressee had to sort the objects in the way that the communicator told them to. And so as a communicator, the communicator had to indicate, because they couldn't see the pictures, which picture the addressee should put where. And to do this, the communicator had to refer to things like the picture with the Empire State Building in it. And what they looked at was how people in these interactions accumulated shared knowledge or common ground over time and coordinated so their communication could become more efficient.

And what they found is that when they had two New Yorkers who were interacting with each other, they tended to very quickly do the task because they could recognize immediately, that person's a New Yorker, and would just say things like, oh, it's the one with the Empire State Building. Whereas when they were talking to someone who wasn't a New Yorker, they had to sort of ground the conversation by establishing these common reference before getting to this point. And so they might start out with saying things like, oh, move the one with the building with the pointy top. And then eventually, they would coordinate on what the actual labels for these things were.

And so Clark's idea is that communication is really efficient, and we're able to do it in the way we are because we're thinking about the common ground we have with other people. And we're able to figure out what kind of common ground we have with others fairly quickly. So if I'm interacting with one of you, I might assume, OK, we both know a lot about cognitive science already. So I can sort of start at a different level than I might start with, say, a child or someone who didn't know anything about this area.

And so this is an important piece of human communication. It seems like-- and Liz talked a little about this, too-- it seems like infants are starting to show some signs of understanding the importance of common ground or shared knowledge in communication from a really early age. But importantly, this seems to come in around the same time that they recognize the importance of speakers facing each other in conversation and perhaps putting together some of their core knowledge domains, which is around nine months to a year.

A lot of work in this domain has been done by Tomasello, who showed that around nine months, children were starting to do something different than they'd been doing earlier. So under nine months, children tend to-- they play with objects, they interact with people, but they don't seem to put these two things together. Whereas at nine months, what they start doing is paying attention, not just to objects or to people, but to objects and people at the same time in

the context of a joint interaction. So they might do things like look at an object and then look at mom to make sure mom is also looking at it. Or they might point at things, not just because they want the things, as a younger child might do, but only to share attention with a parent or with someone else to point out that they're interested in something, and to make sure that the parent is looking and is interested in it as well.

So Tomasello argues that this ability for engaging in joint attention, sharing attention with someone else, to an object or external referent in the world is the foundation of linguistic communication and also cooperation in other very important human activities. And it's certainly going to be important for an understanding of common ground, which is important for communication.

So there's also evidence that around 12 months, infants start to use prior shared experience to interpret communication. I'm going to skip this, I think. But basically, the idea-- well, I'll just go through it quickly-- the idea is that infants will use the activities and objects that they've shared with people previously to figure out what the person means in a new case. So if the infant interacts with one communicator with one toy and with another communicator with a different toy separately, they will figure out the referent of a communicator's ambiguous request by thinking about what information they've shared in the past. So it seems like they're starting to track what kinds of knowledge is shared and what isn't in order to effectively communicate with others.

OK. So there's a lot of other important questions about common ground, but I'm going to skip those now. I just want to come back to the question of why infants' understanding and children's understanding of communication is important for understanding human intelligence. So I think that one reason is that when you think about the insights these philosophers had and how they seemed to be realized in fairly young infants early-- children and infants early in development, when you look at these abilities that humans have and even that very young humans have, and you compare them to what nonhuman animals are doing, things look really different.

And so, just briefly, in animal communication, we see some of the same kinds of features that we see in human communication. So for one thing, animal communication clearly has a social function in the same way that human communication does. So it's socially rich in a number of ways. I'm not going to over specific species, but just to gloss over it, most animal

communication is sensitive to the presence of an audience. So it matters that someone's there to hear your communication. For example, species that produce alarm calls to warn others in their group of predators will rarely produce these calls if there are no other members of their species present.

In many cases, the sensitivity to the audience depends on the identity of the audience. So for example, in some species such as ground squirrels, they call much more in the presence of their kin than when their kin are not around or when there are other individuals there. And in some cases, it seems like there might actually even be a sensitivity to the knowledge state of the audience. So this is looking a little more like the kind of sophisticated communication we see in humans. So a wild chimpanzee, for example, will produce an alarm call, will start to alarm call more if other chimpanzees come over who hadn't heard the original alarm call or who hadn't seen the predator. But if everyone around has already seen it, they'll reduce their alarm calling. So it seems like they tailor it to how much information others around them have had.

However, despite these really interesting ways in which animal communication is social and complex, it's also limited in a number of ways that human communication is not. So the eliciting stimuli for these communicative signals tend to be fairly limited, as do the signals themselves. So there tends to be, say in vervet monkeys, one cry for a hawk and one cry for a snake, and they can't realize new signals for new kinds of predators and situations. As in humans, the receivers-- or in humans, the addressees-- acquire information from the signals of others, but there's no evidence that this information tells the receivers in animal species anything about the mental states of the communicator.

And additionally, the communicator's signals can often cause a response in receivers that's beneficial to the communicator. For example, they get a bump to indirect fitness if they're kin run away and survive predators. So there can be benefits of communication, but there's no evidence that the communicator has any intention of changing the receiver's mental state. So there's really no evidence of this sort of speaker meaning or this special kind of communicative intention we see in humans, which is that a communicator doesn't just intend for the addressee to respond in a particular way, but intends for the audience to respond in a particular way by virtue of having understood the intention of that communication.

And so this is just a, I think, particularly well-worded quote from Seyfarth and Cheney who say basically that listeners can acquire information from signallers, but the signallers themselves

don't, in the human sense, intend to provide that information. So the reason, really, for this contrast between the human and animal cases that I think if we want to build a model of human communication, we need to differentiate it from other kinds of communicative models we could have. And we also need it to develop the types of abilities that human infants have, but taking into account the resources that infants start out with and the developments that we see in the first few years of life.

So it's not going to be enough to have agents that can influence each other's responses or who can understand language, because it seems like the recognition of these more abstract features of communication and its causal effects on mental states is actually present fairly early on as well. And I think just relating this back to Liz's theory that infants might have these different systems for agents, understanding agents and their actions on objects and then for social beings and their interactions with each other. It seems like communication and this type of communicative intention that we see combines these two kinds of things, where you have an intention to produce an effect on someone else, but by virtue of them understanding the mental states that you have toward the world and as well as toward them. And maybe it's the combining of these different domains that helps infants put together their possibly human-unique, but maybe not, communication skills.