Nancy: I am in a brightly lit room with blue and yellow tape on the floor, laid out at a 90 degree angle. On one of these lines is a little five month old baby whose name is Live. Live is on her belly, strapped securely to what looks like a baby skateboard, or maybe a surf board. The skateboard enables her to push with her arms and legs to move, like a turtle moves its body by pushing with its flippers. The advantage of the skateboard is that she doesn't have to support the weight of her body. That way she can explore the world around her without having fully developed the strength to actually crawl. Live's head is covered with a black net cap festooned with very colorful discs. These discs are attached to wires hanging from a movable arm above her. The whole setup has a bit of a Hollywood feel as if Live is a robot baby controlled by the wires.

Audrey van der Meer: Live is not crawling herself yet, but she is rolling over. And the idea is to give babies who haven't started crawling yet the opportunity to move around by themselves.

Nancy: That's Audrey van der Meer, a brain researcher and professor of neuropsychology at NTNU, the Norwegian University of Science and Technology For 40 years. Her research interest has been babies. Leva isn't crawling yet, as I said. So the baby skateboard simulates what it would be like for her if she could actually crawl. The sensors on her head sends signals up the wires so researchers can record what's going on in her brain as she experiences this completely new freedom. Her mom Ina is trying to get Eva to swivel around on the skateboard to grab a rattle that she's shaking. Hi.

Audrey van der Meer: Mm-Hmm <affirmative>. Okay. So I'm going to put leave on one of these yellow lines. Mm-Hmm <affirmative>. And then I'm going to ask Ina the mother to take place behind her baby over there. Yes. And then when you, you can start calling her

Nancy: Most of Audrey's research is focused on the earliest stages of child development, and pretty much all of her research shows this

Audrey van der Meer: Newborns and young babies are much smarter than we tend to give them credit for, and that they are actually born with a brain that is ready to learn. From day one, I think it's just fascinating to realize that a newborn baby, when you hold a newborn baby, it can't even hold up its own head. And then in the course of the first year, that same baby is running up and down the stairs. It's uttering its first words, and it has developed a whole personality of its own. And I, as a developmental neuroscientist, I like to understand the underlying mechanisms that drive development.

Nancy: And not only does your baby know more than you think they do, Audrey has also found that they are already actively learning some surprising things in the womb.

Audrey van der Meer: For instance, we have shown that newborn babies of Norwegian speaking parents that they cry in their mother tongue, which means that they have picked up the characteristics of their native language while they were still inside the womb.

Nancy: I'm Nancy Bazilchuk, and you're listening to 63 Degrees North, an original podcast from NTNU, the Norwegian University of Science and Technology Babies, it turns out, can tell us much, much more about themselves and what language they have heard in the womb. They can tell us what and how they are learning about the world. Today's podcast looks at two researchers and their quests to better understand exactly what babies are telling us and how we can use that information to make their lives better. Audrey, who we have just met, studies infants early movements and has shown that they are

purposeful as the baby makes its first attempts to understand how its body moves and interacts with the world. Our second researcher, Lars Adde studies an infant's spontaneous kicks and wriggles as diagnostic signals early clues to help doctors detect conditions like cerebral palsy long before symptoms fully appear together. Their work bridges medicine and developmental science showing how the tiniest movement of a newborn's limb can offer insight into the magical workings of the human brain.

Nancy: It will probably come as no surprise to you to hear that Audrey van der Meer loves babies.

Audrey van der Meer: I have been thinking about this a long time. Why babies? But I've always, I'm, I'm the oldest of four children. I have loads of cousins <laugh> because my father was the next oldest of 11. So there's, we are a big family with lots of kids always running around and, and doing things. And I was very sure that I wanted kids sooner rather than later.

Nancy: Fortunately, Audrey's husband Ruud van der Weel, was of the same mind both when it came to babies, and when it came to research interests. They did their PhDs together and work and publish together, now, at NTNU.

Audrey van der Meer: We were in the middle of our PhDs when we had our first two <laugh>

Nancy: At this time, the conventional wisdom was that newborns were only capable of reflexive movements like sucking because their brains weren't developed enough to want to control their bodies. But watching her own young children convinced Audrey that infant movements were very deliberate.

Audrey van der Meer: I then noticed that even the earliest arm movements are under visual control. So newborn babies have a genuine interest in their visual arms, and they will work to keep their arms in their field of view.

Nancy: But how do you prove this? How do you show then an infant's tentative movements or deliberate and not just flailing around enter a little ingenuity and a willingness to test out the research protocol on your own infants?

Audrey van der Meer: We had this experiment where we pulled their arms away from the, their face in the direction of their toes by small weights. And we saw that the baby will fight those weights in order to keep their hand in their visual view. And the other hands that are not visual will be pulled down the more weights we added. So that was the first evidence that movements made by very young newborn babies are already voluntary and intentional. So that was, that was my aha moment.

Nancy: An academic article about this research was published in 1995 in Science Magazine, one of the top academic journals in the world. At the same time, Audrey and her husband Ru moved from the University of Edinburgh, where they both did their PhDs to NTNU and they got a big grant from the Research Council of Norway, with which they bought some special brain imaging equipment.

Audrey van der Meer: We purchased the system, which allowed us to look inside baby's brain as they were developing. So that was terribly exciting because before the system that we are using came on the market, it was impossible to test awake baby's brains because you had to glue the electrodes one by one to the baby's head. You had to scrape a little bit in the scalp. It took too long. Babies wouldn't put up with this kind of treatment.

Nancy: The grant allowed them to use nets like I described at the beginning of this episode. In fact, Audrey and her husband actually use several different kinds of nets to study different parts of the brain. Before baby Live and her mom tested the skateboard I described at the beginning of this episode, Live took a different test. She was fitted with a slightly different cap, still covered with discs, and sat in Ina's lap in front of a big video screen, which showed images where colorful balls loomed towards the baby at different speeds and seemingly almost crashed into the baby. All of it was visual, of course. The idea is that babies would blink as soon as they perceived that the balls were close enough so that they might feel as if the balls were going to crash into them.

Audrey van der Meer: The idea is that when babies are only capable of lying flat on their backs, staring up at the ceiling, you don't need advanced neural networks that inform you about distance, direction, time to collision and all these kind of important things. But as soon as the baby has become mobile, it needs to process and pick up this information quickly and reliably and efficiently. We see in our research that the onset of self-produced locomotion in the form of crawling really gives a boost to the baby's brain.

Nancy: The bottom line is that there is an extremely important link between brain development and babies and their ability to move. Not only does this prove to be important in deciding how babies develop normally, but it also explains why Lars Adde our second guest, can use movement to understand when a baby's development isn't going as it should.

Audrey van der Meer: Motor development is the scaffolding for cognitive and language development, because you, it's very difficult to really understand concepts such as below and above and in front of behind and those kind of things if you're incapable of crawling and see what the world looks like from under the table and from up in the curtains.

Nancy: It's not just Audrey's work that shows this. There was an international but inadvertent real world experiment that explored this exact idea. Although that wasn't the intention, that experiment was related to something called sudden infant Death syndrome or SIDS. It started when researchers realized that putting babies on their stomachs to sleep made them much more vulnerable to SIDS. So health officials worldwide started this huge campaign to get parents to put their babies to sleep on their backs. And it worked!

Audrey van der Meer: That campaign worked as a dream. So many fewer babies died in sudden infant death syndrome. But the other side was that parents became wary to put their babies on their stomachs at all, also when they were awake and under supervision. So in the past 20, 30 years across the whole western world physiotherapists and other health practitioners have noticed that the onset of self-produced crawling is much later than it used to be only 20, 30 years ago. If we underestimate babies and don't realize how clever they are and think that development will occur irrespective, then we don't stimulate them the way we should. And one way of what we see is that the brain gets this huge boost after the onset of self-produced locomotion. And that is because understanding cognitive concepts such as in front of and behind is very difficult to learn if you're not able to crawl around and see for yourself.

Nancy: Audrey and her master's student, Julie Blystad, have also looked at the effect of baby swimming on brain development.

Audrey van der Meer: For the first time, I would say, we show that extra stimulation in the early months through baby swimming or through baby massage or, or, or through carrying your baby upright in a sling regularly promotes brain development. So the, the baby swimmers compared to this traditionally raised Norwegian group of babies, which involves in the traditional way of raising our babies, involves that babies spent up to 90% of their awake time flat on their backs. The baby swimmers were advanced in their motor skills, so they started crawling on average five weeks earlier, and they also showed brain development that was much better.

Nancy: I talked to another of the moms who participated in Audrey's work. Her name is Agnes Nymo, and her son Axel was five months old at the time and is her second child. I was curious about what she learned from the experiments.

Agnes Nymo: I think I'm more was more aware of how I behave around him because I realize how much he actually figures out by just how much he learns from us. And you shouldn't just put him down. And he, he learns from everything. And I noticed actually what this morning that he sticks his tongue out a lot. I do that too and <laugh>. So I just become more aware of how much they learn just by lying there and observing, and not looking like they learn a lot.

Nancy: Audrey is now in Brazil following up on that fascinating finding. She told us about early on in the podcast. She's collecting data from Portuguese speaking moms who she's asked to record their newborns when they cry.

Audrey van der Meer: We have found that Norwegian babies cry differently and then French babies, Arabic babies, Italian babies, and that the, the Norwegian babies, they cry in a more singsong kind of manner, and that reminds of Norwegian or Scandinavian. And we have reasoned or found that they need to have picked up these characteristics of their native language while they were still inside the womb.

Nancy: These recordings aren't just about discovering that babies hear language before they're born and pick up some of the characteristics of that language.

Audrey van der Meer: But this has implications, of course, for babies born with a hearing deficit because they would then, if, if we are right, they would cry in a, in a different way, not characteristic of their native language.

Nancy: We all know that early detection of any kind of developmental challenge is important so that doctors and healthcare specialists can begin helping the child as soon as possible. And that brings me to my next guest, Lars Adde.

Nancy: Lars Adde didn't start out his professional career thinking he would be a researcher with a quest. He started as a physiotherapist in the neonatal intensive care unit at the hospital here in Trondheim. Working with the tiniest patients poses multiple challenges, but one of the biggest was figuring out whether the babies in the unit might be at risk of developing cerebral palsy. This is more than an academic question. Between eight and 10% of children who are born with a known risk factor, such as premature birth or an infection or breathing difficulty will develop CP. That's not a small number, especially if you're one of the parents of one of these infants.

Lars Adde: Cerebral palsy is caused by some kind of trauma in the brain during birth or during before birth, during pregnancy, or the first two years of life. And it's a kind of trauma. It's could be d different kind of brain damages. It, it could be a, a hemorrhage, it could be an infection, it could be different kind of things. But there is an a trauma to the brain. And the consequence is mostly motor impairments, right? So that you are spastic and cannot move your body and the muscle, you cannot control your muscles in a normal way. So it's a quite big functional limitation.

Nancy: You can't cure cerebral palsy, but with physical therapy and other interventions, you can really reduce the impact on the growing child's life. And most importantly, the earlier you can intervene with different measures, the better. It was about this time that Lars working with his tiny patients, heard about a technique being developed in Europe that helped healthcare providers diagnose cerebral palsy at an extremely early age. So this is the story of Lars's quest one that would transform him from a healthcare provider to a medical entrepreneur. It's a story that I'm going to tell in six acts.

Lars Adde: So in a particular time window of infant development, and this is between week 12 and 18 after the term age. So in this time window, if you put an infant in supine position and the infant is awake, the infant will spontaneously just move a lot in the body. It's like small dancing movements in the whole body. And it's like the infant is orchestrating the world right and away, right while waving the arms, arms and legs and things like that, that

Nancy: These movements are called fidgety and they're a good sign. Best of all is that these movements or the lack of them can be observed when the infant is as young as three to four months old. No, or few fidgety movements mean the infant as at risk of developing cerebral palsy. The credit for this discovery goes to an Austrian researcher named Heinz Prechtl. Until Prechtl's work, it hadn't been easy using more traditional methods to get a solid diagnosis until the baby was one or two years old, in part because there's no definitive blood test. And because cerebral palsy isn't just one specific set of symptoms, it can be mild or quite severe. Al's work in the late 1990s led Lars and many others to use his findings to diagnose cerebral palsy as early as possible. And there's an important biological reason for trying to get that early possible diagnosis.

Lars Adde: That is a challenge for the child with cerebral palsy because you lose time when the brain plasticity as is its optimal phase to really do intervention.

Nancy: It's not just the child who loses out from getting a later diagnosis. Lars and his colleagues have interviewed parents about getting an early diagnosis and published this research. The bottom line is that parents really want to know.

Lars Adde: Yeah, because if you know early, it gives you the possibilities of doing the best for the child. And some parents have also communicated in the interviews that when they get the diagnosis of cerebral palsy at let's say about two years age, they will always carry a kind of grief because they know then, okay, if I had known earlier, could I have done something for my child?

Nancy: Lastly, an earlier diagnosis would also mean that the healthcare system could focus on the children who need it, rather than monitor children who might be at risk, but who will actually never develop this condition that saves everyone time and money. So let's call this Act One in Lars's long journey from physiotherapist to medical entrepreneur, first, he and several colleagues from his

department decide to get trained in the Prechtl technique called the General Movement Assessment Technique.

Lars Adde: So we trained our brains in the General Movement Assessment technique, and we did a lot of studies implementing this tool in the clinical follow up program here at the hospital from 2002 to to 2019. We used this a lot in clinical study.

Nancy: They took videos of the infants so they could have more time to review each case. Not surprisingly, some cases were borderline. Maybe there was a problem or maybe not. That meant that just one trained clinician watching for an infant's fidgety movements wasn't enough. So Lars and his colleagues built a team of three, which could all look at the same videos to render a diagnosis. Turns out however, that they were in a minority in the larger society of hospitals across the globe.

Lars Adde: We realized that this observational technique was really not taken on board in clinical practice around the world.

Nancy: In some ways that seems incredibly surprising. Why wouldn't you want to get the earliest possible diagnosis in a situation like this? Well, like many things in life, the answer boils down to time and money.

Lars Adde: You need a lot of training. It's quite expensive to take these courses and to take this education, you also have to practice all the time to observe videos. So the sustainability of really having these general movement assessment teams in hospitals, all the places they are needed, it's not possible in practice.

Nancy: Enter Act Two of Lars's quest: Lars and his colleagues started brainstorming solutions

Lars Adde: And I was thinking, oh, these movement patterns, couldn't we measure them in some way?

Nancy: First, they needed a collection of videos of infants from across the globe to establish what was normal and what would be an indicator for cerebral palsy. So that's what they did.

Lars Adde: We set up multi-site center studies, clinical studies. So we cooperated with four hospitals in Norway. We cooperated with two big hospitals in Chicago, in the United States, and with a big hospital in the southern parts of India and also in Belgium, Denmark, Turkey.

Nancy: All of these research sites use the same standardized video setup so the videos could be compared. Eventually. Larist collaborators collected videos of about 600 infants and followed the infants all the way until they were between three and five years old. That meant they knew without a doubt, which infants would eventually develop cerebral palsy.

Lars Adde: So we got the data about which infant had this cerebral palsy diagnosis, so we had the truth, right?

Nancy: At this point. Lars had a PhD research fellow from NTNU's Department of Computer Science working with the team. So why not use computers to analyze the videos? We'll call this Act Three of Lars's journey.

Lars Adde: So the first thing we did was that we developed tracker that made it possible for us to track 19 body points from the digital video image. So we trained an AI algorithm to do motion capture from 19 different body points. So to say it in a simple way, we were sitting with 20,000 frames from different videos and we were annotating where is the nose? Where is the right and left wrist? Where is the right and left ankle? So we clicked in this positions manually in 20,000 frames. And then we use this data to train an AI model to automatically track these positions from videos.

Nancy: It's a great idea. The infant is in a home setting and it's less stressful for everyone. But Lars and his colleagues needed to prove that these home videos were equally useful as those made in the hospital. And a study they did, showed home videos worked. Now any family that is being followed up after a stay at the NICU is asked to do a video recording of their infant at home before they come in for their three month checkup.

Lars Adde: We are then doing this clinical observation as our routine doing this general movement assessment. But in addition, we now track the movements using our AI algorithm. And then we have through clinical studies, we have also developed an AI algorithm that have found a correlation between the movement data from the 19 positions and the cerebral palsy or no cerebral palsy diagnosis. So the AI model, how the connection between the spontaneous movements and the CP diagnosis between three to five years age using these 19 body key points,

Nancy: But don't expect to find the solution in doctor's offices anytime soon.

Lars Adde: I cannot use these research developed models for patient care in the clinical setting to use these kind of tools to the patient, you need to transfer the research results to a medical device. The software is a medical device. We have these medical device approvals that are needed. Now we have also got the a AI act from the EU from Europe, and the Norwegian government is now working on deciding, using the AI act also here in Norway. It is not decided yet, but it'll be. And that gives a lot of regulatory issues about using a tool like this in patient care.

Nancy: Enter Act Four of Lars's quest, translating all this information into an actual usable tool for medical doctors. Complying with these regulations requires addressing one of the most puzzling and intriguing aspects of using AI. The way that AI makes judgements is kind of opaque. That's why computer scientists refer to the AI's internal assessment processes as a black box. Lars and his colleagues are now trying to open that black box and understand how AI makes its predictions. They actually have to do this to get the tool approved as software that doctors could use with their little patients.

Lars Adde: We have the data from the 19 body key points from the video. So we have the movement data. So what we know is that the model in some way are using information from these 19 body key points to establish the risk for cerebral palsy or not. But we cannot explain which of these 19 key points the model is using. Is it using all of them? Is it using just some of them, just one of them? We don't know.

Nancy: After three years, Lars and his colleagues finally found a few answers.

Lars Adde: We have indications now that the model is probably using the movement data from the wrists and ankles quite a lot. So that means that it uses the extremity movements quite a lot.

Nancy: Now things are getting pretty interesting. Early on in this journey, Lars reached out to NTN News's Technology Transfer Office, which everyone calls the TTO. As a university employee, you're required to do this if you have something you think could be commercialized, but like the rest of Lars's Quest, this was anything but easy.

Lars Adde: The TTO thought it was a good idea. So we started the process first trying to identify possible industrial partners that could be interested and that the idea was to establish if possible, some kind of license agreement. That means that an industrial partner could license the solution from the university, but the IP for the solution is still at the university.

Nancy: That seemed like a good idea, but remember how I said that eight to 10% of newborns who spend time in the NICU, the neonatal intensive care unit, could develop cerebral palsy. That's a big number if your child is in that risk group. But here's another way to look at it. The incidences of cerebral palsy in Norway is two per thousand live births in real numbers. That translates to roughly 108 children in Norway in 2024 because the total number of births that year was a little more than 54,000. In other words, this was not necessarily a huge market.

Lars Adde: What we realized is that it was not straightforward to get an industrial partner on board on taking the idea. So we used two, three years trying to do this. We then got the idea, okay, let's try another way. It's a hard way, it's a difficult way, it's a probably a long way. And that was to establish a startup company ourself.

Nancy: Enter Act Five. This new company is called In Motion Technology and has just two employees, including Lars call it a genuine startup, but they have a mock-up of how their AI tool could be used by doctors as an aid in diagnosis. LAR showed me how this software works and what the tool might look like.

Lars Adde: So this is a typically developing infant Yeah, with typically movement patterns. So what we see here is fidgety movements. It is like you can imagine it like a little breakdowns, you know? And what is typical about this movement pattern is that all body parts are involved at the same time. It is variable movement patterns. And what they found and what we see in the general movement assessment, the clinic, the clinic meant when you have all these variability in the movement patterns, that is a good sign. That means that the brain is really orchestrating a lot of variability in the movements.

Nancy: I also wanted to see what an infant at risk would look like.

Lars Adde: This infant is also in a supine position. The infant is moving spontaneously, but the quality of the movement patterns is quite different. The movements are much more stiff, they are more monotonous. You lack this kind of variability. So it's much more stiff, monotonous, and sometimes it looks like what we call almost like cramped movements. So the fist, this exactly fisting in the hands, for example. So you have you have spontaneous movements, but the quality of them are very different. So this is in fact what we call the lack of these fidgety movements. The fidgety movements that are variable are not there. And this is a sign that gives this child a higher risk. So this child that you are observing now was, was later on confirmed on having cerebral palsy. So I'm quite sure that our AI model is using this kind of information when it's classified into high or low risk for cerebral palsy.

Nancy: Lars described how their AI tool can help doctors evaluate risk because the whole idea is to give clinicians support in making their own decision, not in having the AI tool make decisions for the doctor.

Lars Adde: We can present a CP risk value for every five second time window of the three minute video, and we can display that in a graph and we can show this graph in parallel with the infant video. That means that the clinician cannot observe the infant's movements in the way they are trained to do. And in this same thing a way they can observe the output from the AI model. In parallel, this gives them a possibility of continuously evaluating the output from the model and compare it with our own knowledge.

Nancy: Now we're at Act Six of Lars's journey: Finding investors.

Lars Adde: So now we are in a position where we are knocking on doors to investors trying to get some money to build a software solution that could be tested in clinical settings and, and get this medical device approvals.

Nancy: Lars is 63 years old now and in Norway, he can continue working in his current position until he's 72. He hopes by then he'll be able to retire with this one tool available for doctors to use.

Lars Adde: I have been in the clinical field, I've been researcher for many years, and now I'm also an entrepreneur. So I had three hats, so lot, lots of hats. So it's a little bit challenging, but it's very fun. From the beginning, my motivation was to find new tools to give a better help to the small infant

Nancy: Here's hoping he succeeds!

Nancy: I'm Nancy Bazilchuk, and you've been listening to 63 Degrees North, an original podcast from NTNU, the Norwegian University of Science and Technology. My guests on today's show were Audrey van der Meer, Lars Adde, and Agnes Karin Nymo. Special thanks to Ina Welve and her daughter Live, who graciously let me record them as Audrey tested them in the lab. You can see a selection of the research this podcast is based on in the show notes. And while my section on Lars mostly focused on his work, he wanted me to give a shout out to his collaborators, Ragnhild Støen from the NICU at St. Olavs Hospital; Siril Osland and Toril Fjøtoft, physiotherapists and GMA experts at St Olavs Hospital; Inga Strümke, Daniel Groos and Espen Ihlen, AI development at NTNU; Kristian Rathe and Eivind Andersen, NTNU TTO; and Kjell Arne Jacobson with in Motion Technology.

Nancy: Now it's time for me to give my own shout outs because this is the last episode of 63 Degrees North. I'm retiring next summer and we at the university agreed it would be a good idea to stop the podcast at the end of season five. So there you have it.

Nancy: I want to give a big thanks to my colleagues: Anne Sliper Midling who helped me argue that NTNU really should have an English language podcast, my Gemini journalist colleagues, Nina Tveter, Sølvi Normannsen, Steiner Brandslet, and Idun Haugan, all of whom have listened to me talk about how to solve writing problems; Heidi Kultorp, my supervisor now, who actually understands what it takes to produce a podcast all by yourself. And to Sigrun Engen, head of the NTNU Communication Division, who has also had my back.

Nancy: Thanks to Randy Lillealtern who helped me learn the trade, and thanks to the hundred or so researchers who willingly sat down and talked to me for hours about their work.

And finally, thanks to you, my listeners, especially people who sent me fan mail!

Thanks for listening.