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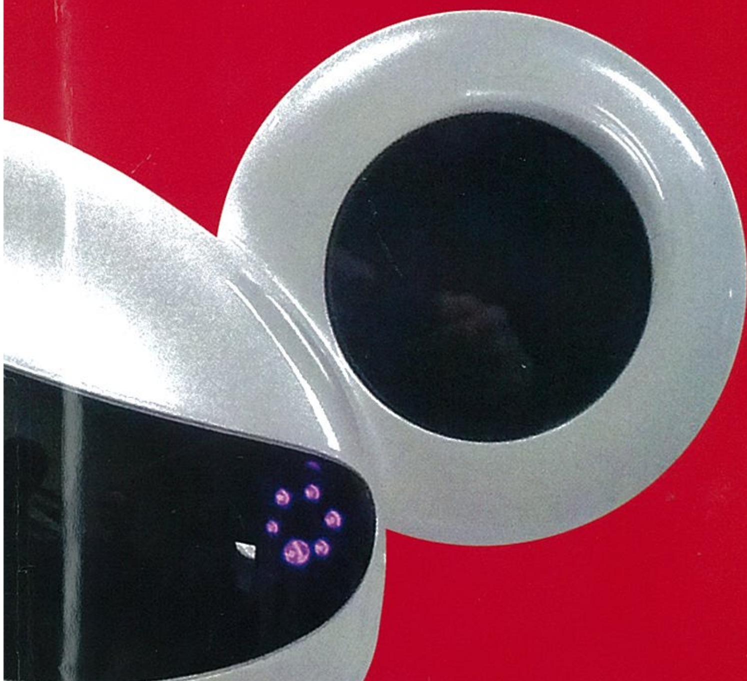
How megagaming can bring history to life



Rise of the machines

- Meet the robot that can help fix early speech and reading problems
- Could artificial intelligence solve the recruitment crisis and end testing?

Ofsted warns of crackdown on schools that 'game' league tables

Le Vooc: the French system that could revolutionise online vocational courses

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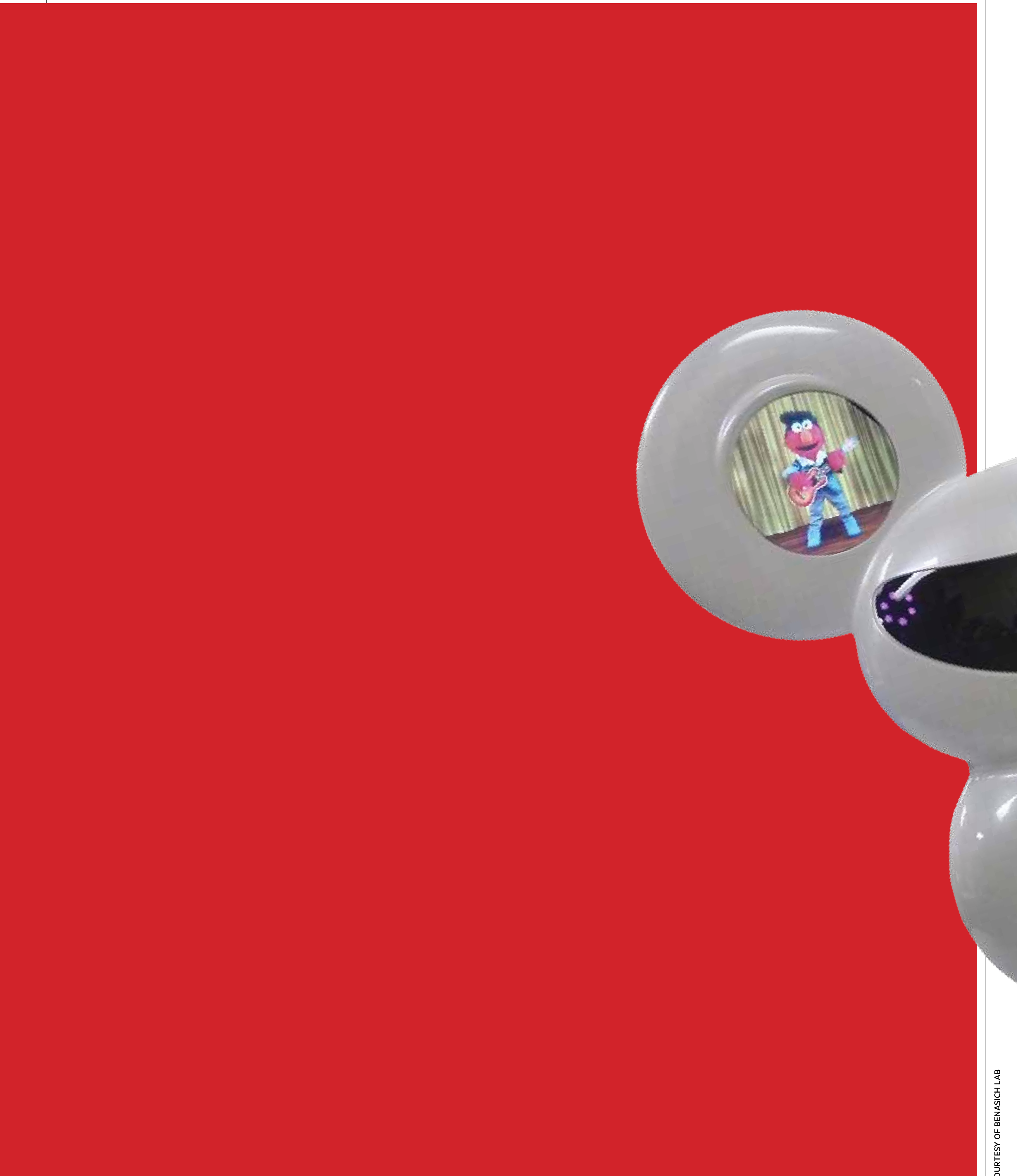
Carol Dweck: how to 'pass on' a growth mindset

Small talk, BIG impact

Could a new language intervention for babies really narrow the ability gap and put children on a level playing field by the time they go to school? Kat Arney takes a closer look at the robot that, its inventor claims, can identify early speech and reading problems – and fix them



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This year, the world was introduced to the Babypod – an intravaginal speaker designed to plug into a pregnant woman's phone and play music to her developing foetus.

The idea of this was not to provide the soon-to-be baby with some chill-out tunes while they waited to be born. Rather, the aim was to stimulate the child's language and communication skills, ready for life in the outside world.

It was the latest in a long line of interventions aimed at boosting babies' brainpower, from playing Mozart in the crib to bedazzling newborns with high-contrast picture books. And that's the reasonably sane end of the spectrum. It's easy to write all these products off as placebo gimmicks for middle-class parents wanting to reduce their anxieties about their child being "left behind". But, if the latest research is to be believed, and if the right tool is used, there could be something in it.

The past decade has brought an explosion of scientific studies into the underlying processes at work in the brain as infants learn to decode the sounds in the world around them and assemble them into spoken – and eventually written – language. There is now strong evidence that you can predict a child's ability to learn language. Perhaps more interestingly, there are even suggestions that, with the right intervention, you could "fix" any problems so that almost every child could start school at the same reading level. In fact, a US scientist called April Benasich believes that she may have developed that very intervention.

'At birth, babies can discriminate every sound of every language in the world'

Encased in tiny sensors

There's something more than a little unsettling about seeing a picture of a baby with its head encased in a net of tiny sensors, bristling with wires that twist and trail towards a box of electronics. But this kit, known as an EEG (electroencephalogram), is harmless. It non-invasively measures the tiny electrical impulses flickering through an infant's brain as it carries out a task.

By carefully tracking these brainwaves as babies hear different sounds, scientists are able to build up a detailed picture of the changes that happen as infants begin to decipher the sounds around them, figuring out the lilts and cadences of their mother tongue and filtering out non-language sounds.

One of the most exciting researchers working in this field is Benasich, professor of neuroscience at Rutgers University in Newark, New Jersey. Enthusiastic and passionate about her work and its implications, she has dedicated her career to understanding babies' brains and behaviour.

"At birth, and probably even before, babies can discriminate every sound of every language in the world," Benasich says, speaking via Skype from her home on the snow-stuffed US east coast. "So how do they do that?"

Her research has shown that they achieve this feat by listening to tiny variations in the sounds around them and working out whether they're likely to be parts of words or not. From there, they use information from the speech they hear around them – from mum, dad, the TV, or anyone else in the vicinity – to assemble this knowledge into the components of language.

"What happens is that there are representations – what we call acoustic maps – getting set up in the brain," she says. It's these maps in our brains and their subsequent

refinement that are enabling the pair of us to chat fluently across the Atlantic in English, our shared native language.

"Over time, babies gradually do something called perceptual narrowing. They first set up these pre-linguistic maps, and as they hear more and more things in their environment they gradually begin to ignore sounds that are not part of the language – you can see that in the changes in their brain patterns."

Benasich has been mapping changes in these brain waves on to different components of language. Notably, specific patterns in waves known as theta oscillations seem to correlate neatly with phonemes – the small chunks of sound that make up words.

"A phoneme is a sound like *ba*, *da*, or *ka* – it's a little piece of language," she says. "In order for children to set up language, and particularly in order to set up reading, they have to be aware that these little sounds they hear are part of a bigger thing."

The differences between the onset and intensity of the consonants in the phonemes *ba* and *da* can be measured in tens of milliseconds, but they each produce a distinctive pattern of electrical impulses in the brain, which can be picked up by Benasich's hairnet-like baby EEG. Just by looking at the EEG traces as a six-month-old baby hears and maps different sounds, Benasich

‘Once the baby is strapped into an infant seat, the robot gets to work’

From nursing to neuroscience

A self-confessed “weird, geeky little kid”, AABy’s inventor, April Benasich, quickly skipped ahead, reaching her final year of high school aged just 15, with a couple of high-profile scholarships to her name.

But because of her young age, her father was reluctant to let her go to college, insisting instead that she study nursing at Mount Sinai Hospital School in New York.

She qualified at 18, after getting special permission to take the licensing exam three years early. She then married at 19 and quickly had two children.

In search of something more intellectually stimulating and scientifically minded, she headed first to Princeton and then to New York University, eventually gaining two doctorates – the first in experimental and cognitive neuroscience and the second in clinical psychology.

Impressively, she did all this while supporting herself and her children (aged 4 and 7 at the time) as a newly single parent.

Now established as the director of the Infancy Studies Laboratory at Rutgers University in New Jersey, she works across a range of scientific disciplines to find an answer to one of the most fundamental questions about our humanity: how do we learn to talk?

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> ‘Benasich says she can predict with 90 per cent accuracy whether a baby will have language problems’

says that she can predict with 90 per cent accuracy whether they will have language problems by the age of three and be likely to struggle with literacy later on.

“We can predict [from looking at the EEG] if they’re going to be below or above average. And our hypothesis is that there’s a subset of kids that end up having learning disorders, like specific language impairment and later dyslexia, who have trouble with this type of mapping,” she says.

Hereditary component

There’s a large hereditary component to the diagnosis of language problems. If a baby is born into a family where one or more members has a language learning issue, they’re at higher risk of developing similar problems, but this isn’t guaranteed. Indeed, it’s currently impossible to predict whether any individual child is going to suffer problems, and they can only be diagnosed once language difficulties start to manifest themselves. Or at least that used to be the case.

“I can look at those babies and tell you which ones are going to have problems and which ones are not,” says Benasich. “And I can look at kids that were born into families with no history, no genetic impact, and I can also tell you [whether they’re going to have language issues] just by looking at the efficiency and accuracy with which they handle the sounds that are coming in, because those are the building blocks. That’s what’s lying underneath the language, supporting the incoming language information. And if that foundation is crummy, they’re going have problems.”

It’s not just Benasich who has come to this conclusion. Her work fits with observations from neuroscientists around the world who are using a range of techniques to probe babies’ brains, adding important pieces to the complex puzzle of language development (for example, see this review from Patricia Kuhl, professor of speech and hearing sciences at the University of Washington: bit.ly/BrainMechanismsResearch).

The science here is clearly of interest to schools on a general level, but what will really make teachers sit up is how Benasich is taking this research and building on it, moving it from an interesting neuroscientific phenomenon into a tool that she says might prevent potential language problems from manifesting themselves.

That’s quite a claim, with equally big implications. Disparities in the literacy levels of children starting school are a major issue for teachers, and something numerous academics and organisations have looked at. For example, the Save the Children report *Ready to Read*, released last year, states that: “By the age of five, most children should be able to speak in full sentences and use most of the everyday words that adults use. They should be asking lots of ‘why?’ questions to understand the world around them, and should be able to talk confidently about the past and the future.”

It’s a reasonable target, but one that is missed by nearly one in four English children by the age of five.

Some of this difference is down to exposure to language at home during the early years of life. In their article “The early catastrophe”, published in the journal *American Educator*, US researchers Betty Hart and Todd R Risley describe how children from families on welfare hear about 616 words per hour, while those from working class families hear twice that number and kids from professional families hear roughly 2,153 words per hour. Extrapolating out, they conclude that “a child from a high-income family will experience 30 million more words within the first four years of life than a child from a low-income family”. Meanwhile, research from the UK-based educational and social mobility charity the Sutton Trust suggests that there’s a 19-month gap between the richest and poorest pre-schoolers in terms of school readiness.

Over the years, research has attempted to find possible solutions for this problem, mainly focusing on increasing the amount of time that parents spend communicating with their children during the first couple of years of life. Furthermore, a report commissioned at the tail end of the last Labour government by the Department for Children Schools and Families (now replaced by the Department for Education), drawing on a study of nearly 10,000 children born in the mid-1990s in the Bristol area, found that early ownership of books and trips to the library at the age of two are a strong predictor for school readiness.

In March, charity Save the Children made another suggestion in its report, *Lighting up your brains*, calling for qualified teachers to be employed by nurseries to ensure the development of children’s language skills.

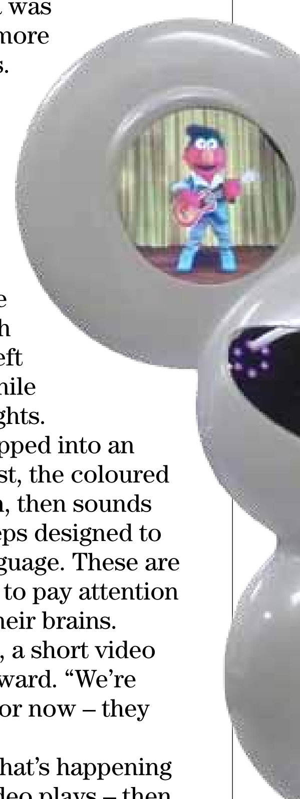
The impact of poor language and literacy skills not only hinders a child’s ability to learn – and leaves them behind when they start school – it can have an emotional and practical impact, too, as Kathy Hirsh-Pasek, psychologist and infant language specialist at Temple University in Philadelphia, explains.

“The effects are huge,” she says. “Imagine not being able to communicate effectively your wants and desires. It makes you a more frustrated person and it mucks up your social interactions.”

In addition, according to a recent report from the US Department of Justice, “the link between academic failure and delinquency, violence and crime is welded to reading failure”, with a staggering 85 per cent of juveniles in the court system and 70 per cent of the country’s prison population struggling to read.

Contemplating the personal and societal costs of poor literacy, Benasich didn’t want to just diagnose a potential problem but to try to fix it, too.

Drawing on previous research with rats showing that it is possible to influence and even reprogramme the animals’ responses to sounds, her idea was to find a way to train babies to set up more effective language maps in their brains.



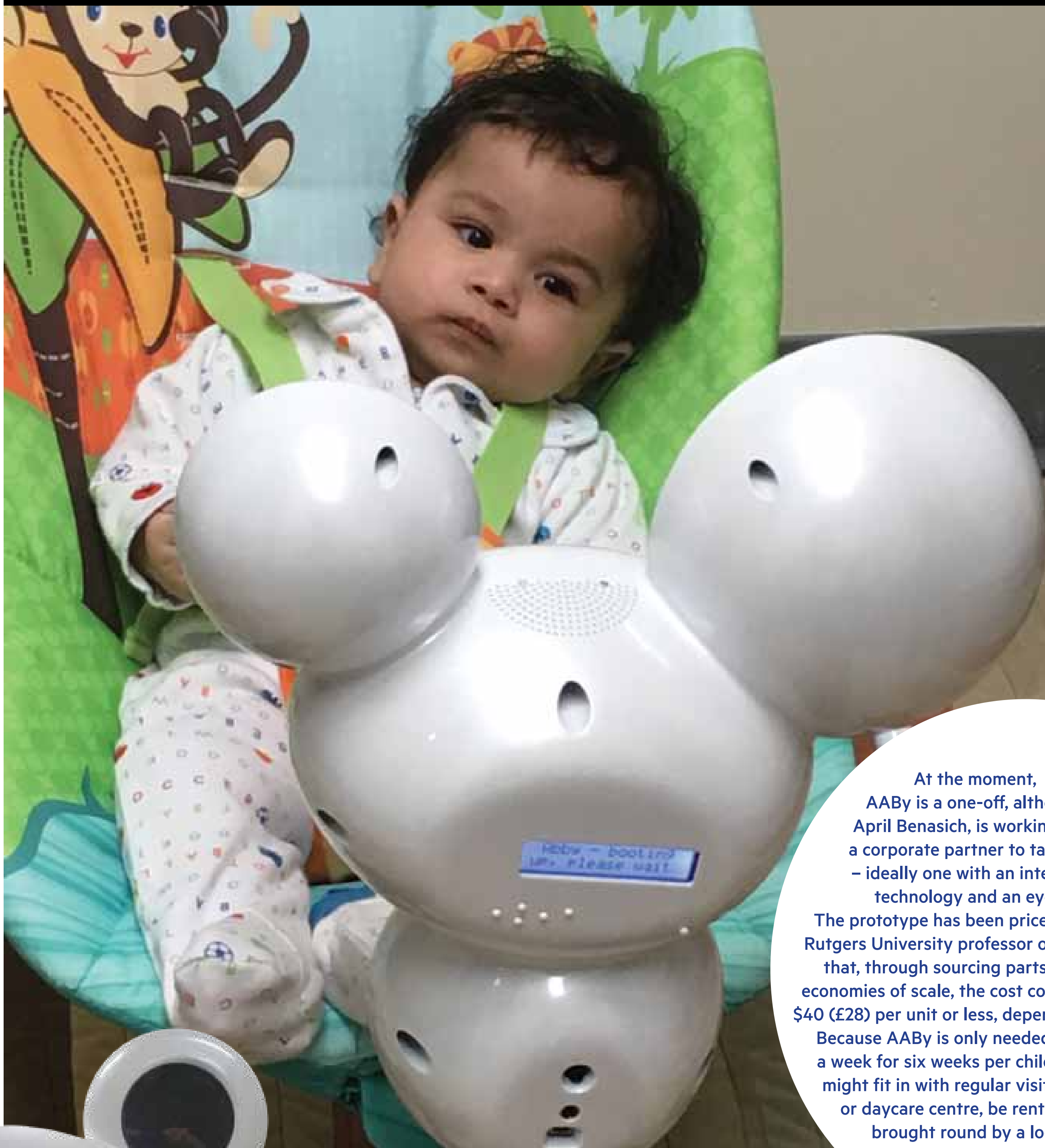
The solution came in the form of AABy – a pearlescent white robot with the bubble-shaped contours of a cartoon mouse, designed to be used with babies as young as four months old. Perched on a bendy tripod, the prototype has a black plastic semicircle across its “face”, like the visor on a motorbike helmet, which contains an eye-tracking device. The left “ear” contains a small video screen, while the right-hand one flashes with LED lights.

Once a baby is put in front of it, strapped into an infant seat, the robot gets to work. First, the coloured lights flash to grab the child’s attention, then sounds start to play – swooshy-sounding sweeps designed to mimic the complex tones found in language. These are the exact kinds of sounds babies need to pay attention to as they develop the sonic maps in their brains.

Then, just as the tone subtly changes, a short video clip plays on the screen, acting as a reward. “We’re using little snippets of *Sesame Street* for now – they love it!” Benasich laughs.

Once the baby has got the hang of what’s happening – that when the sound changes, the video plays – then

What AABy did next



At the moment, bubbly robot AABy is a one-off, although its inventor, April Benasich, is working hard to persuade a corporate partner to take the idea forward – ideally one with an interest in educational technology and an eye on social good. The prototype has been pricey to put together but the Rutgers University professor of neuroscience is hopeful that, through sourcing parts off the shelf and basic economies of scale, the cost could come down to around $40 (£28) per unit or less, depending on the manufacturer. Because AABy is only needed for less than 10 minutes a week for six weeks per child, it's easy to see how it might fit in with regular visits to the doctor's office or daycare centre, be rented for a small cost or brought round by a local health visitor.

the real training can begin.

Watched by the eye tracker, the baby learns to recognise when the sound changes, flicking its gaze towards the video screen in anticipation of the dancing puppets. If it gets it right, then the tasks get harder, pushing them to disentangle subtle shifts in tone and complexity. If the baby's attention starts to waver, the LED lights flash again to snap them back into it. And if the baby falls asleep or loses interest altogether, the unit eventually switches off.

In total, Benasich's team is aiming to achieve six weekly sessions of just six to eight minutes per child, so it's hardly an arduous workout. Each child's individual progress is stored, ready for the training to be picked up again in another session, and the results can even be sent by Bluetooth to a parent's mobile phone.

Impressive results

Does it work? AABy grew out of research carried out by Benasich and her team using a similar but more high-tech lab set-up. They tested 49 four-month-olds, measuring their brain responses before and during sound training sessions and then again three months later. A third of the group got active training, with the sounds getting harder as they got better at spotting them changing. Another third passively received a random mixture of easy and hard-to-discriminate noises, which they couldn't control, while the rest weren't trained at all. The results, published in the ➤

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Journal of Neuroscience in 2014, were impressive. "What we found was that there was this huge improvement in acoustic mapping, so the babies that had the active intervention responded very quickly and efficiently. They process the sound really well and can separate it out into different categories – we could see the shapes of the waves, and say 'Yes, they're getting this!'"

She also noticed that the passive group improved as well, compared with infants who didn't get any training time, but it wasn't as much of a big bump up. Following the babies further, Benasich has exciting preliminary results suggesting that the training might provide a boost for language development by 18 months.

So language problems in children are solved? Not quite. This is very early research and Benasich is unwilling to make any substantial claims as yet. She's reluctant to do so until all the data is in and have been published, and it's certainly too soon to speculate that the intervention will help kids to read who might otherwise struggle.

Also, the idea of intervening in the first year of a baby's life is not without its critics. Hirsh-Pasek, for example, urges caution. "To give you one example, most kids have normal beating hearts," she says. "There will be some who will have problems, does that mean every single child should wear a heart monitor? I think one has to be somewhat careful here, or we will have so many gizmos and gadgets for well-developing children that are really completely unnecessary."

She points out that babies have managed to learn language and literacy perfectly well for hundreds of years without any interventions other than parents and other people talking and reading with them. And although she's supportive of Benasich's work and believes that the results are solid, she is concerned that it could be used to sell unproven gimmicks to middle-class parents, whose children are already at an advantage in the lottery of life.

"I can't tell you the disdain I have for the market capitalising of psychological science," she says. "What I would hate to see is a crib turned into an intensive care spaceship, and I think what it does is adds to the culture of fear that parents have. As the psychologist Steven Pinker said, just as spiders spin webs, humans are designed to learn language. And baby humans are well equipped to do that."

Benasich doesn't see this as a way of mechanising a natural process, however, rather as a way of boosting it. And, she hopes, it will be something that gives every child an equal chance of success at school.

"Our goal is not to make the babies do things all in the same way," she says. "Our goal is to give them the information that they need to be able to do a better job of what they're doing naturally – to help them to be their best, to have the most optimal sound-processing system that they can.

"This kind of intervention may make them more able to take advantage of what's in their environment. If you change the threshold so that the subset of kids that really need help are much more efficient, I think you could actually shift the distribution of the number of kids that have learning disorders, so I hope that it will make a big difference."

Kat Arney is a science writer, broadcaster and author of Herding Hemingway's Cats – Understanding How Our Genes Work

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