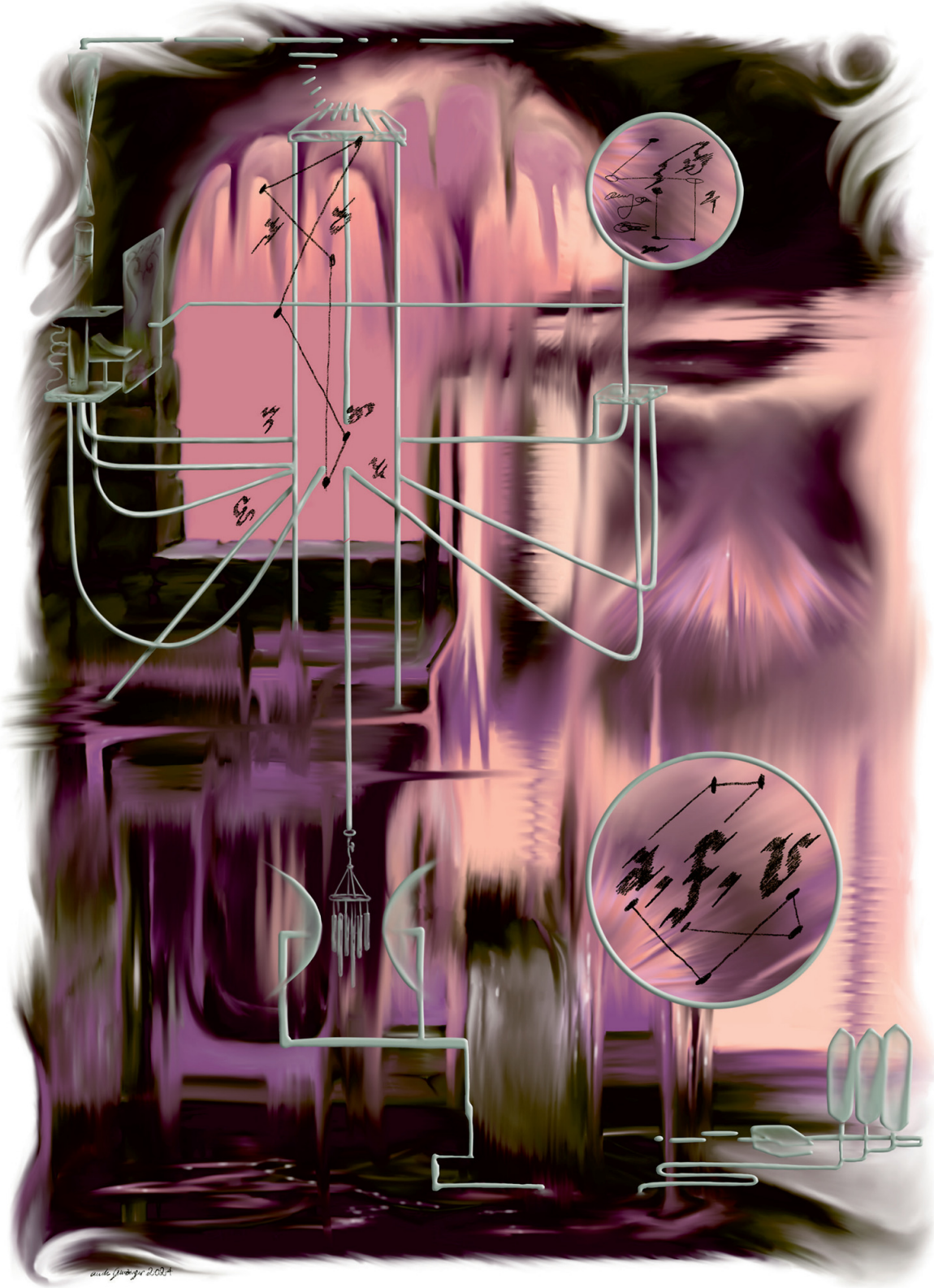
OPENING THE BLACK BOX



Musica Ex Machina

An exhibition on the history of music and computation explores the potential of clockwork mechanisms, symbolic notation and algorithmic innovation in composition

By Robert Barry
Illustration by Aude Gunzinger

It is not much to look at. Housed in a Perspex case in a waist-high plinth in the middle of the gallery, there remains something rather humble about the device itself. It's only about 30 centimetres tall and roughly the same across, somewhere between the size of a compact microwave and a child's lunchbox. Mottled brown and grey, with brass and cogs and wheels, it looks much of a piece with the mechanisms at work in feats of engineering broadly contemporary with it: Victorian pumping stations, telegraph switching stations, bascule bridges. It might almost be the innards of some giant's pocketwatch. But for many, both in its own time and even more since, it has represented a dream of almost limitless possibilities.

Charles Babbage's Difference Engine, of which the object in front of me is but one small portion, on loan from the Whipple Museum of the History of Science at Cambridge University, is often lauded as the beginning of something: the first automatic calculator, the first computer, even the first thinking machine. Ada Lovelace, Lord Byron's daughter and Babbage's mentee, is regularly cited as the first programmer.

To Lovelace, an accomplished musician herself, the machine might just be the first mechanical composer. "Supposing," she wrote in 1843, "that the fundamental relations of pitched sounds in the science of harmony and musical composition were susceptible to such [algorithmic] expressions and adaptations" – note the conditional tense here; Lady Lovelace is not sure – "the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent." If we suppose that music can be abstracted into figures and manipulated as code, then it might be possible for this machine to wrangle that code into a piece of music. She doesn't say that music will be good or even pleasant, but it could be of any "complexity" or "extent". Even the qualities by which such a music might be judged are abstract, measurable, quantifiable.

Seeing the gadget here, however, in the middle of EPFL Pavilions' Musica Ex Machina exhibition, I am inclined to see it less as the beginning and more as the end of something. In the context of a history of "computational thinking" in music stretching back almost a millennium, Babbage's Engine looks every bit the heir to such mechanical automata as Ismail al-Jazari's 12th century musical boat and Henri-Louis Jaquet-Droz's 18th century clockwork organist. This is a legacy of wondrous machines and ingenious devices. Their workings were concealed. The whole point was to amaze and astound.

Babbage, always a man of practical concerns, showed his workings. His Engine might now exemplify a brief window of disenchantment before the arrival of ever more inscrutable electronic devices in the 20th century. But whereas an intelligent and enquiring mind, in the 12th century or whenever, might have opened up al-Jazari's boat or Jaquet-Droz's mechanical musician and seen clearly how they work – just as they might conceivably trace the path of functions through Babbage's cogs and wheels – no one will ever crack open the case of a MacBook Pro and 'see' how Garageband works. We live today in a world of impenetrable black boxes. They are all making music (of any degree of complexity or extent). And most of the people who use them to make music have absolutely no idea how they really work.

It is probably true to say that almost all the music you hear today has been affected by these black boxes in some way. Whether it's a digitally remastered recording of a 16th century madrigal or a free improv live set played by musicians who grew up listening to CDs of John Coltrane and AMM, or a Spotify playlist of recent club bangers that might have spent their entire lifespan, from the artist's first sketch to their ultimate domestic consumption, inside a laptop's central processing unit, the contemporary musical landscape is overwhelmingly shaped by the fact of computers, their capacities and their limitations. Jennifer Walshe would go further. "Music has always been – and continually is in the process of being – changed by the introduction of different technologies," the Irish composer said at a symposium to mark the opening of the exhibition in Lausanne, Switzerland. "I believe that all future music is going to be affected by the affordances of different machine learning systems – whether or not the musicians used AI to write it."

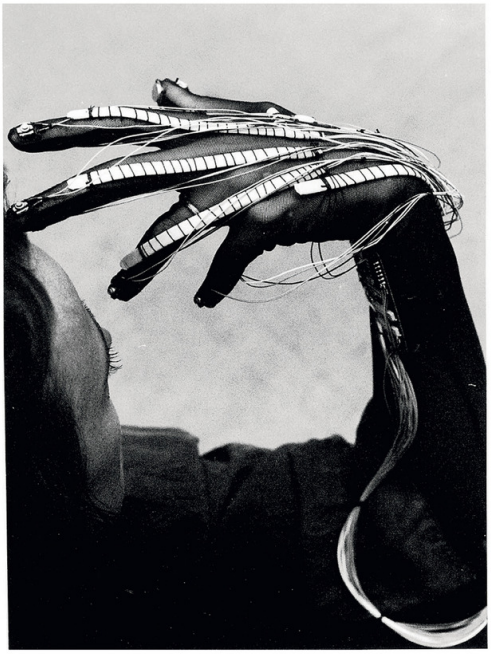
Musica Ex Machina is described as an exhibition about "computational thought in music". Asked what that means, one of the four curators of the show, Paul Doornbusch, said, "Computational thought is usually considered algorithmic thought, where you can work out the solution to a 'problem' by following some steps to solve it." In that sense, as Doornbusch granted, this is something "characteristic of human intelligence". But the way different technical objects embody that intelligence presents a model of the social relations between people at different times.

If, for instance, we look closely at the illustration of al-Jazari's boat included in the exhibition, we can see a water wheel beneath the deck powered by the waves on which the boat is floating. The wheel then powers in turn the movements of four small human figures holding musical instruments: a drum, a harp, a flute, and so on. As the water flows, the wheel turns, the hands of the human figures move over their instruments and the music plays. According to an analysis by Professor Noel Sharkey of Sheffield University, the drummer's rhythms could even be 'programmed' into different patterns by changing the placement of the pegs that connect it with the cam shaft below. The animated instrumentalists themselves are all wearing brightly coloured qaba, a long robe of Turkic origin. We know from the text in al-Jazari's manuscript that they are intended to represent a group of qiyān, that is, enslaved girls (and probably most of the music al-Jazari himself had actually heard performed in public was undertaken by female slaves). During the Abbasid Caliphate, in al-Jazari's lifetime, qiyān were often highly skilled and well-educated, sometimes rising to positions of considerable power and influence. They could also be bought and sold as commodities.

One of the most intriguing items in the exhibition is a small piece of cardboard, just over 21 centimetres long and six centimetres wide. Attached to this are three thin strips of paper with different letters and numbers printed on them, bound together by a pair of linen straps, with a movable window in the middle to highlight the correspondence between figures on the different strips. This is the slide rule used by Arnold Schoenberg to work out the pitch relations in his 12-tone compositions. It is practically indistinguishable from the kind of slideable reckoning devices found ubiquitously in the toolkits of engineers before the advent of handheld scientific calculators in 1972. Schoenberg was born into a middle class family in Vienna towards the end of the 19th century, and his little jury-rigged computing device presents music not as a relation between slaves and masters but as a kind of rationalised industrial production, with the composer himself something like a factory foreman.

For all their many differences, what both of these composing machines share is an image of music as work. They are effectively labour-saving devices consistent with the relations of production

Illustration of Ismail al-Jazari's 12th century boat automaton



Laetitia Sonami with the *lady's glove 4.0*

in the societies that produced them. It makes a striking contrast with many more recent visions of technologically assisted music. For the French computer scientist François Pachet, director of the Spotify Creator Technology Research Lab, the question of music creation using artificial intelligence has been solved – at least for "well-defined problems". His concern is primarily with how to get people to swallow it, which doesn't seem to be going so well. Drawing on his own research at Spotify, he reveals that around a quarter of all listeners will skip playlisted tracks within the first five seconds – and that's just talking about music that has been algorithmically curated, let alone generated.

Pachet has been working in this field for a long time. I first met him in 2013, when he was still at the Sony Computer Science Lab and working on the kinds of things that today, over a decade later, are the stuff of viral YouTube channels: training software to imagine Charlie Parker playing dodecaphonic music like Schoenberg or Paul McCartney's "Yesterday" but as if it were Bob Dylan. At the time he spoke to me of a desire to turn creative work "into a fun game". Nowadays, he finds himself worried about what he calls "the IKEA effect", a cognitive bias leading people to think more highly of goods they have played a part in assembling. It was supposedly first discovered by the mid-century manufacturers of Betty Crocker's cake mix, which only found success after they removed the powdered eggs, requiring home bakers to add their own fresh (the story, it turns out, is a myth, but an influential one). This, Pachet concludes, is "irrational".

The problem as he sees it today is how to sell a bunch of gullible prosumers on a more or less instant powdered music (ironically, historians now attribute the improved fortunes of Betty Crocker's baking formulas to the burgeoning autonomy of American housewives in the early 1960s, not the placatory demand for additional ingredients dreamed up by some canny executive). Later the same day, American artist-researcher Marek Poliks pointed out that the economics of streaming have created a situation where "the 21st century musician largely makes money by the performance of being a musician to supplement their actual careers in affiliate marketing, content marketing or events marketing". In Spotify's 'creator' economy, the labour of music as music is quietly disappeared.

The first computer ever to take on this labour itself is little known today – an "understandable" omission, according to Doornbusch, since "most of the history is written in the USA". Designed by British engineer Trevor Pearcey in Sydney in the late 1940s, the CSIR Mk 1, later renamed CSIRAC (Commonwealth Scientific and Industrial Research Automatic Computer) was among the first generation of electronic computers. It worked much like earlier machines such as Alan Turing's Enigma-cracking Bombe and the postwar Manchester Baby, but where the latter had a little bell to tell you when a program had run its course, the CSIRAC had what was called a hooter.

One day, programmer Geoff Hill realised that if he sent multiple pulses to this miniature loudspeaker at different rates he could make it play a tune. This new ability was first showcased at the Australian Computer Conference in August 1951, probably as a bit of a wheeze. Nobody thought to record it at the time, but Doornbusch has recreated it by reading the indentations of the old punchtape by hand, translating that into standard ASCII files and then running it through a software simulation of the old CSIRAC machine. You can hear it in the exhibition playing a crunchy, square-wavey version of FJ Ricketts's "Colonel Bogey March" (best known today as the tune to which Allied troops once sang *"Hitler has only got one ball"*). "It turns out," Doornbusch told me, "to be the earliest use of a computer to play music." But it's far from the oldest exhibit in the exhibition.

The timeline of Musica Ex Machina begins with the creation of modern musical notation, first by the 11th century monk Guido d'Arezzo (who developed the symbolisation of pitch) and later elaborated by Ars Nova theorists like Johannes de Muris (who worked out how to show the note lengths as well). The starting point is justified by the contribution these theorists made to music's "codification" (as per the exhibition booklet and wall texts). On that basis, it might just as well have started a millennium or so earlier with the notation used in ancient Greece or even Babylon. It is notable, however, how little thought of that earlier form of musical symbolisation was by its contemporaries. Aristotle's pupil Aristoxenus, probably the most important music theorist in Athens in the fourth century BCE, regarded the notation of his day as trivial and uninteresting, accusing anyone who made use of it in musical analysis of a "profound and invincible" ignorance. That prejudice against writing survives in musicology to this day. What's fascinating about the innovations of Guido and de Muris, however, are the new ways of manipulating musical material that it made possible.

In the early 15th century, French composer Baude Cordier constructed elaborate musical notations in the shape of a heart, canons written out on a circular stave. Around 1480, Josquin des Prez's *Missa Di Dadi* appears to have used dice rolls to algorithmically manipulate the melodies in a setting of the Ordinary of the Catholic Mass (with the dice faces helpfully illustrated at

Courtesy the National Museum of Asian Art, Smithsonian Institution (Ismail al-Jazari); F Hoelzema (Sonami)

the side of the staves). In our own time, Colombian composer Alejandra Cárdenas discovered that working directly with programming languages in open source live coding programmes like SuperCollider and TidalCycles not only made her feel "immediately closer" to her chosen instrument, the computer, but also offered her a different sense of musical time. Speaking over Zoom in November 2024, she referred to the distinction between two Greek terms for time, chronos and kairos, with the latter referring to a less linear, more cyclical temporality, emphasising passing instants and what Cárdenas called "synchronicities". In her installation at EPFL, a musical composition is represented as a kind of ocean with images of whales and fragments of code floating about, which audiences can move and transform by scanning a QR code on their phones. It's a very different image from a standard score.

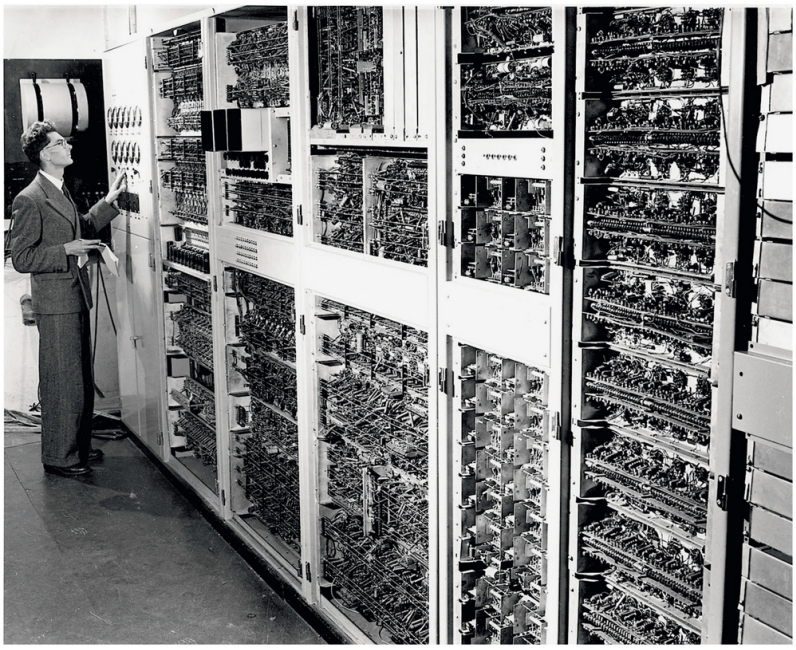
The work of Cárdenas and des Prez shows how the creation of music isn't separate from the way it is symbolised. The one engenders the other. Representations have consequences. Interviewed at Bergen's Borealis Festival in March 2020, George E Lewis told me that when he first started working on his own interactive software Voyager in the late 1970s, the image of artificial intelligence provoked a certain "resistance" to his work which "didn't just come from white people who were concerned about having people poaching on their presumed territory. It also came from non-whites, especially African-Americans, who somehow felt that the electronics were threatening a notion of identity, which was premised on a sort of a spurious idea of the natural."

The anthropomorphic image of automated computer systems as a kind of "artificial intelligence" runs deep. Just five years after the CSIRAC learnt to hum "Colonel Bogey", a headline in the *Champaign-Urbana News Gazette* in Illinois ran "Mechanical Brain Takes Up Composing Music". The article concerned Lejaren Hiller and Leonard Isaacson's *Illiac Suite*, a string quartet composed using Markov Chains, a process whereby an analysis of the probability of a given event such as one particular musical note being following by another in a given corpus (such as the chorales of JS Bach) is used to generate rules which then govern the automatic generation of new works. It wasn't just tabloid newspapers. Programmers like Alan Turing and companies like Bell Labs were already talking about "electronic brains" in the 1940s. Such language positions the computer as a kind of artificial person, like the monster in Mary Shelley's *Frankenstein* or the slave girls on al-Jazari's boat. But Laetitia Sonami, a sound artist who has been working with so-called machine learning systems for some ten years now, balks at such language. "There's no sense of an agent that's outside of me," she said. "I was interested in training the system not to learn."

Few artists have done more to find new ways of thinking and speaking about this strange new world of algorithmic composition than Jennifer Walshe. In 2023, her essay "13 Ways Of Looking At AI, Art & Music" offered up a whole slew of new possible metaphors, from "AI is Fan Fiction" to "AI as Companion Species". In the exhibition, her work *ULTRACHUNK* (2018) with Los Angeles based creative technologist Memo Akten involved training a large language model on a year's worth of Walshe's spontaneous vocal improvisations in front of a webcam in order to generate a constantly morphing video stream of the composer's face with this weird cyborg vocal track, which sometimes sounds uncannily voice-like but also glitches, stutters and contorts itself in a way that is unmistakably digital. Improvising with this output live felt like "trying to manage a powerful non-human entity, which might spiral out of control at any moment".

One of the oldest stories we have that deals with a kind of automatic composition concerns the 64th Bishop of Rome. From the time of the emperor Charlemagne, the entire corpus of Western plainchant was traditionally attributed to Pope Gregory I who is said to have received this vast quantity of liturgical music from a dove (who was really, of course, the Holy Spirit in disguise) singing into his ears, leaving the venerable monk to simply transcribe what he heard, much as Hiller and Isaacson notated the punch card outputs of the Illiac computer.

In a journal entry from 20 September 2018, while she was right in the middle of training the ULTRACHUNK system, Walshe transposed this story of Pope Gregory into an image of an "anchorite futuristic nun in a cell singing to an AI". Music here figures as something like a gift from the heavens or the language of birds. But as Walshe pointed out to me recently, to most teenagers today, AI isn't wondrous or magical any more. It's just the thing that does their homework for them. And yet the workings, and all the hidden labour and weird biases that come with them, remain concealed. We might not be able to escape the temptation to anthropomorphise computers. But in the face of a looming landscape of an infinite powered music mix that nobody even cares to listen to, I do hope, as Walshe demands at the end of her essay, that we might start to "think much, much weirder". ● *Musica Ex Machina: Machines Thinking Musically* continues until 29 June at EPFL Pavilions, Lausanne, Switzerland



Trevor Pearcey at the CSIR Mk 1, later known as CSRIAC

Courtesy CSIRO Archive