All-rounder AI?
Artificial intelligence is versatile, but still needs to learn a lot

CLEARLY FEASIBLE
Cost of achieving climate targets calculated

SIMPLY DIFFERENT
Not every autistic person feels ill

TRULY SUCCESSFUL
Martin Winter counts on lithium-ion batteries
Under control

Everybody is staring at “Igor”, spellbound. The white box will be ready in a moment. The measurement of its neutron radiation is expected to reveal: has there been any radioactive material put aside? International experts have used the portable detector in the exercise “Nuclear Disarmament Verification” (NuDiVe) at the Jülich Institute of Energy and Climate Research (IEK-6), in which they tested new methods for monitoring nuclear disarmament. The procedures could clarify in the future whether a nuclear warhead has been properly destroyed. Until now, this proof has hardly been possible because inspectors are not allowed to inspect weapons systems directly. This is intended to protect a state’s military know-how.

Free access to knowledge

Reading scientific journals is no longer supposed to cost anything in the future.

Cover Story

Learning machines

Artificial intelligence raises high expectations – and offers many opportunities. However, it is still a long way from real intelligence.

Research

Full of energy

Keeps to the facts and follows his gut feeling – portrait of battery researcher Martin Winter.

Climate neutrality clearly calculated

How to convert the energy system successfully by 2050 at the lowest possible cost.

News in Brief

Turbo test for drinking water

In epidemics and after disasters, clean water is vital. A new device is to shorten tests.

Simply different

People with autism: when hugs scare people.

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Research in a tweet 32
Samples

Does that sound familiar? You heard this song the other day, and you liked it right away. Yet you remember neither the title nor the name of the performer. Annoying. But then, weeks later, exactly this song can be heard on the music app on your own smartphone. Coincidence? Maybe, maybe not – because artificial intelligence (AI) may have unraveled the secret of your musical taste. AI is actually also used to evaluate which music you listen to and then suggest new songs according to the pattern. This proposal, then, was by all means perfect. Wait and see what AI will suggest next. In the meantime, you can read in our cover story what patterns AI should look for in science: for example, in weather data in order to warn of local weather extremes, or in images of brain scans in order to predict the long-term course of a disease.

Jülich researchers are also working on solutions for our future in other areas: for example, they are calculating how Germany can reduce CO₂ emissions by 95 per cent by 2050 at low cost, and they are developing various battery systems. You can also read why a hug is as difficult for people with autism as complicated grammar is for others. We hope you find here and there the right sample piece for you. Please enjoy!

Your effzett editorial team

In the famous thought experiment of the physicist Erwin Schrödinger dating back to 1935, a cat in a closed box is simultaneously alive and dead according to the rules of quantum mechanics. This superposed state does not end until someone checks. With the aid of smartly applied lasers, an international team with Jülich participation has succeeded in putting 20 atoms into one such superposed “cat state”. The previous maximum value was 14 superposed atoms. The new record is a further step on the way to a quantum computer that could far surpass classical computers in solving certain tasks.

– PETER GRÜNBERG INSTITUTE –

Ensuring the supply of electricity and food at the same time – this is what Food & Energy plants are intended to do in Africa. Solar roofs over fruit and vegetable fields generate electricity, which flows into the local supply network. The land underneath the photovoltaic systems can be cultivated in “open greenhouses”. This combination is intended to reduce land use conflicts between agriculture and energy production. Experts from Nigeria, Benin and Germany are involved in both the production and the conservation of field crops, for example in modern drying plants. The aim is to cure fruit and vegetable surpluses from the harvest period for longer storage, thus ensuring a constant supply. Jülich coordinates the project.

– INSTITUTE OF ENERGY AND CLIMATE RESEARCH/INSTITUTE OF BIO- AND GEOSCIENCES –

Schrödinger’s cat with 20 atoms

In the famous thought experiment of the physicist Erwin Schrödinger dating back to 1935, a cat in a closed box is simultaneously alive and dead according to the rules of quantum mechanics. This superposed state does not end until someone checks. With the aid of smartly applied lasers, an international team with Jülich participation has succeeded in putting 20 atoms into one such superposed “cat state”. The previous maximum value was 14 superposed atoms. The new record is a further step on the way to a quantum computer that could far surpass classical computers in solving certain tasks.

– PETER GRÜNBERG INSTITUTE –
Energy-saving data storage from individual atoms is still a long way off. One reason for this is their lack of magnetic stability. Researchers from Hamburg, Jülich and Leiden in the Netherlands have discovered that this can be improved by a certain symmetrical arrangement of the atoms. They had systematically investigated different positions of three to nine iron atoms on one surface. – PETER GRÜNBERG INSTITUTE –

Full speed ahead

The Jülich physicist Dr. Benedikt Sabass has received a “Starting Grant” from the European Research Council in the amount of around €1.5 million. The young scientist wants to investigate the mechanical forces of bacteria, for example of hospital germs. These forces affect how cells behave. – INSTITUTE OF COMPLEX SYSTEMS –

Puzzle with atoms

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– PETER GRÜNBERG INSTITUTE –

Faster to the breakthrough

Forschungszentrum Jülich and Google will conduct joint research on quantum computers in the future. Prof. Kristel Michielsen, head of the Quantum Information Processing research group at the Jülich Supercomputing Centre, explains the background.

Mrs Michielsen, why is Google an interesting partner?

Since 2011, Google has been working on its own quantum computer. The cooperation gives us access to hardware and know-how from Google. “OpenSuperQ”, a sub-project of the European flagship for quantum technology in which Jülich is involved, benefits from this, albeit indirectly.

What does Jülich contribute to the cooperation?

Our supercomputer infrastructure as well as our software and hardware know-how. I myself test algorithms on supercomputers that could run on quantum computers. In addition to the scientific exchange, we want to support each other in the training of specialists. However, Google is not the only partner.

Who else is on board?

We are collaborating with D-Wave and engaging in talks with IBM. We need to network more closely to help quantum computers achieve their breakthrough more quickly.

CHRISTIAN HÖHLFELD ASKED THE QUESTIONS.

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The waters hit the place without warning. On 29 May 2016, a thunderstorm cell erupted over Braunsbach in a very short time. As much rain fell within one hour as would normally in months. A huge flood wave made its way through the village and swept away everything that stood in its way: trees, cars, walls of houses. It left behind about 50,000 tons of rubble in the village northeast of Schwäbisch Hall. Total damage: over €100 million.

Even though the weather forecast has become more accurate over the years – it is still difficult for meteorologists to issue timely warnings of heavy rain or local thunderstorm cells for specific places such as Braunsbach. This is partly due to the relatively coarse resolution of the German Weather Service’s (DWD) regional weather models. “Anything smaller than two kilometres will fall through the grid. The model will then say, for example, that it rains in an area measuring two by two kilometres – even if in reality blue skies and rain alternate in the area. It is usually not enough to reliably predict precipitation locally,” explains Dr. Martin Schultz.

In the DeepRain project, the physicist from the Jülich Supercomputing Centre is therefore trying to improve the forecasts so that the authorities will have sufficient time to warn of local thunderstorms and heavy rain. Artificial intelligence (AI) is to make this possible. It is to search for patterns in weather data that announce local weather extremes.

RULE-BASED CALCULATION

AI is an approach to replicate intelligent behaviour using computers. The machines learn, draw conclusions and correct themselves. However, they are still far from reaching the human brain. Our brain is more energy-efficient than any other machine; it can draw meaningful conclusions from just a few examples; it is particularly capable of thinking flexibly, finding unconventional solutions and drawing connections between completely diverse facts.

Machines, on the other hand, have an advantage when it comes to stoically ploughing through mountains of data and tracking down hidden patterns or recognising much more complex patterns in a mass of information than humans can.

Classical face recognition methods are a common example: AI sorts the photos of different people by, for example, pupillary distance, face shape and nose size – depending on what the programmers have specified. It then creates a pattern for each face. After that, it applies its knowledge to new pictures: it compares a picture with the present photo stock and suggests who can be seen on the picture. So AI is being taught to judge new data sets. This is one of the simplest forms of machine learning.
THE PATTERN OF RAIN

In the improved weather forecast that Martin Schultz is aiming for, the machines need to be able to do a little more to recognise patterns. “Weather data contain complex temporal and spatial patterns. We don’t know which of them are typical for heavy rain. We therefore feed the software with as much data as possible. It searches for patterns itself and then makes forecasts,” Martin Schultz uses an advanced form of machine learning: deep learning. In this, AI systems also search large amounts of data – in the case of DeepRain, weather data from previous years. However, the researchers do not specify what is characteristic of extreme weather. Instead, they train the machine to find out for itself.

“We don’t know what patterns AI is looking for. These can be things that we haven’t even begun to think about or that we might never have recognised,” says Schultz. At the end of the day, however, he and his colleagues can check whether the AI forecast is correct, such as if it rained heavily on that day, and can then report this back to the software. Through constant repetition, AI “learns” which patterns best predict heavy rain.

The functioning of deep learning is roughly similar to the learning processes of our brain. Countless billions of nerve cells are interconnected there. In this way, they pass on information and process it. When we learn, we use certain connections between nerve cells again and again, thus changing the network between the cells: in children who read a lot, for example, the connections between the areas of the brain responsible for vision, hearing and speech are strengthened. In professional badminton players, the network of the brain regions that coordinate vision and movement changes.

Deep learning uses simple mathematical units, the activity of which roughly corresponds to that of nerve cells in the brain: they are also linked via input and output connections and receive information from other units that process and forward them. However, they function much more simply than the biological models. The mathematical units are organised in layers.

THOUSANDS OF LAYERS

“Deep networks for deep learning sometimes have hundreds to thousands of layers in which the data is processed,” explains Dr. Jenia Jitsev, who is working on the architecture of such models at the Jülich Supercomputing Centre. In face recognition, for example, it is as if the input image passes through a variety of filters that respond to increasingly complex patterns. The first layer only perceives brightness values. Deeper layers react to edges, contours and shapes, while even deeper layers eventually react to individual characteristics of human faces.

The network learns to identify a given face by remembering the combination of brightness values, edges, shapes and details that characterise this face: as with the nerve cells in the brain, certain connections between the network units are strengthened and weakened. The learning process creates connection patterns that lead to the correct result. “Deep neural networks need as many different training examples as possible: the more different examples it gets, the more successful the learning,” says Jitsev.

AI on the rise

As early as 1956, the term of artificial intelligence was coined at a several-week workshop at Dartmouth College in New Hampshire. First concepts for artificial neural networks already existed at that time. In the 1970s, however, the long “AI winter” began: research stagnated due to a lack of both computing power and sufficient training data. Around the turn of the millennium, the renaissance of machine learning began.

“No big data and progress in learning algorithms have made the current progress of artificial neural networks possible,” says deep learning expert Dr. Jenia Jitsev from the Jülich Supercomputing Centre: the more data, the more examples with which an artificial neural network can be trained. And the more intensive the training is, the better a network can correctly classify new examples it has never seen before.

Such self-learning AI algorithms are, however, very computationally intensive. “Here, we benefit from the increased performance and storage capacity of modern high-performance computers, which have been specially developed to handle such algorithms and huge amounts of data,” In addition to conventional processors (CPUs), many graphics processors (GPUs) can be found in such high-performance computers. GPUs may indeed have slower cores than CPUs, but they still have a decisive advantage: unlike CPUs, they have thousands of cores that can perform simple computing operations in parallel with great efficiency. This is ideal for the functioning of neural networks and deep learning: during their training, a large number of such operations have to be carried out repeatedly.

High-quality software adds to the ever more powerful computers. “Meanwhile, many different open source tools are available. “The three prerequisites – big data, powerful hardware and suitable software have – finally awakened AI from its long hibernation.
This is exactly one of the problems that Schultz still has to solve in the DeepRain project: there is a lack of training material. “We transfer 600 terabytes of data from Deutscher Wetterdienst [German meteorological service] for our calculations. That doesn’t sound like a shortage in the first place.” However: heavy rainfall is rare. “According to statistics from Deutscher Wetterdienst, there were no more than eight such events at any one station between 1996 and 2005,” says Schultz. Accordingly, data sets from which a pattern for the AI could crystallise are rare.

Furthermore, the data is not only required for training, but also for the final quality test. According to deep learning expert Jenia Jitsev, “Typically, only 80 per cent of the data is used for the training phase. The remaining 20 per cent won’t be touched at first. This test data set is retrieved only after the training in order to test the capabilities of the neural network.”

INDIVIDUAL FORECASTS

This test phase is particularly important when it comes to sensitive data – data that determines the fate of people, such as the selection process for applications, the assessment of creditworthiness or medical diagnoses. Prof. Simon Eickhoff from the Institute of Neuroscience and Medicine (INM-7) is working on the latter. Using AI, he someday hopes to find patterns in the brains of people with psychological and neurological diseases so that they can be treated specifically and individually.

For example, computer programs are to search brain scans for patterns that provide information on how likely a relapse is in a patient with depression. AI could predict how quickly impairments in a person with Parkinson’s disease will progress or whether a patient can be treated better with drug A or with drug B.

THE OVERALL PATTERN COUNTS

However, there is still a long way to go. Eickhoff and his team are already working on using pattern recognition to enable AI to obtain certain information from brain scans: at the moment, the focus is on cognitive performance and personality traits such as openness, sociability and emotional stability. For this purpose, Eickhoff and his team have trained machine learning programs with the brain scans of hundreds of people. Certain psychological parameters of these test persons are also entered, such as the reaction time in a standardised test. If the model has seen enough data, it can deduce the reaction time of a new individual from the brain images alone. “However, our algorithms do not search for individual aspects in the image data. We can’t say that, in people with a good working memory, certain areas of the brain are larger than average. Rather, the overall pattern is decisive,” says Eickhoff.

According to the brain researcher, more complex cognitive abilities, such as reaction times or the capacity of the working memory, can be deduced relatively reliably from brain scans using AI. Even though the prediction also tends to be correct in the case of personality traits, it is not that accurate yet. Quality assurance with data that AI does not yet know reveals this: it only trains with one part of a data set at a time. The researchers use the rest to check how well the AI predicts personality traits after a learning phase.

AI already provides very good results in predicting age and gender. “Here, our program can indicate with a certainty of 90 per cent whether the brain belongs to a woman or a man. Regarding age, it is in the range of plus/minus four years,” reports Eickhoff.

BRINGING LIGHT INTO THE DARK

The verifiability of data such as age or gender is comparatively simple. It becomes more difficult with diagnoses and prognoses. “The acceptance of artificial intelligence in healthcare hinges on the trust placed in it – by both patients and doctors,” believes the Jülich expert. Trust is partly based on the fact that it is plausible how a diagnosis or a result comes about. However, in deep learning, AI experts like to compare a neural network to a black box: you know the input data and get an output. However, the processes in the information-processing layers in between are so complex that it is usually impossible to understand how the network arrives at its results. It is therefore an important task for the AI experts to shed some light on
Not only medicine and neurosciences would benefit from such machine-generated solutions that our brains cannot find,” says Eickhoff.

ARNDT REUNING

Networking data and knowledge

Medicine, climate research, aerospace: the variety of disciplines for which AI plays a role is also reflected within the Helmholtz Association. In order to support cooperation and the exchange of knowledge and data within the research network, the association is currently setting up an interdisciplinary platform for which it provides long-term funding of € 11.4 million annually – the Helmholtz Artificial Intelligence Cooperation Unit (HAICU).

“As the central unit, Helmholtz Zentrum München links several Helmholtz centres that form local units with thematic focus. Jülich covers the area of key technologies/information in particular,” says Dr. Timo Dickscheid, AI expert at the Institute of Neuroscience and Medicine (INM-1). “Each local unit consists of a fully equipped young investigator group and a high-level support team that supports other scientists in their projects with AI expertise.”

Dickscheid’s research group “Big Data Analytics” will play an important role for the Jülich segment. It creates a highly accurate model of the human brain, the resolution of which will reach down to individual nerve cells. To this end, the group is further expanding deep learning methods in order to analyse microscopic image data at a magnitude of several terabytes. AI is to learn to automatically detect microstructures, map brain areas and assemble thousands of tissue sections into 3-D views of the brain. The group wants to develop solutions that can also be used in other research areas – such as learning with only a few training examples.

The research group “Cross-Sectional Team Deep Learning” of the Jülich Supercomputing Centre (JSC), headed by Prof. Morris Riedel and Dr. Jenia Jitsev, is also involved in the Jülich unit of HAICU. Together with the new high level support team of the JSC, it will promote and support research into machine learning and deep learning. The focus is further expanding deep learning methods to improve models of the human brain.

Hear more about Timo Dickscheid’s research at effzent.fz-juelich.de/en

What’s what?

ALGORITHM
A series of instructions to solve a certain problem (see also Knowing-it-all, p. 28).

The individual commands must be unique and executed step by step. An algorithm usually requires an input and returns an output. Examples of algorithms are computer programs and electronic circuits, but also building instructions or cooking recipes.

Certain algorithms are attributed to artificial intelligence.

ARTIFICIAL INTELLIGENCE
Machines that emulate intelligent behaviour on the basis of algorithms.

An exact definition is difficult because the concept of intelligence itself is not clearly defined. As a result, AI includes a whole spectrum of methods, disciplines and applications: computer programs that can play chess or, alternatively, robots that chat with social network users. Certain subareas of robotics are just as much part of AI as expert systems which are to help make optimal decisions in a limited range. To an increasing degree, ethical, social or legal considerations are also part of AI. Machine learning is regarded as a key technology within the AI.

MACHINE LEARNING
AI algorithms that learn from data and examples to solve problems.

They acquire “knowledge” by means of examples (training data) or through independently recognising patterns in data. This enables them to subsequently assess unknown data of a similar nature. When identifying faces, for example, an algorithm can learn that pupillary distance, face shape and nose size are crucial factors for recognition. For the “face” concept, the algorithm extracts a characteristic pattern from each image. The more data the algorithm has at its disposal, the more precise the recognition becomes. Considerable progress has been made in recent years with the help of artificial neural networks.

Learning strengthens, weakens or changes the connections between individual cells. Advancements in computer technology and the availability of large amounts of data have enabled deep learning in such artificial networks.

DEEP LEARNING

Here, too, algorithms analyse large data sets and can then evaluate unknown data of a similar nature. However, the network models are much more complex due to the many layers. As a result, the algorithm has many degrees of freedom in which to network and, in order to solve a task, can independently learn to extract optimal and possibly very complex traits. When identifying faces, it can thus discover finer criteria than pupillary distance or nose size that are helpful for recognition. Programmers help the software “to learn” by giving feedback on whether a result is right or wrong, but they do not correct the process.

ARTIFICIAL NEURAL NETWORKS
Mathematical models inspired by the way the brain works.

Signals – the input data of the algorithm – are fed into interconnected units, referred to as “mathematical nerve cells”. The artificial nerve cells process the information and generate further signals using simple mathematical equations, which they pass on to subordinate “cells”. Finally, an output layer generates a result. There can be several layers of these nerve cells which are linked to each other in different ways: between the input layer and the output layer,
His chemistry teacher merely attested to his good performance at school – no more, no less. Today, Martin Winter is the face of German battery research. The success story of a man who keeps to the facts and follows his gut feeling.

That wasn’t my thing at all,” he says, leans back and laughs. The 54-year-old is sitting in the “visitors’ corner” of his office. Jeans, shirt, high forehead, alert eyes that keep an eye on his counterpart, Honorary professorships, certificates and awards hanging on the walls tell of motivation, commitment and a due portion of ambition: “I’ve always worked hard, I admit it. But the effort has paid off: the number of successes far outweighs the number of failures!”

The snow white coat hangs neatly on the coat rack, the bookshelves are orderly, next to them a rack, the bookshelves are orderly, next to them a clear desk – everything seems tidy. It fits into this picture that Winter has a penchant for stamps – for him, illuminating topics from different perpectives and pointing out pros and cons in order to find the best solutions is an attitude towards life. On this basis, he is responsible for the major lines of research at both the Helmholtz Institute Münster, a Jülich branch office, and the “Münster Electrochemical Energy Technology” institute (MEET). His most important and faithful companion besides his keen mind: his gut feeling. “There are situations in which I have gathered all the facts, but still can’t get any further. My gut feeling is crucial then.”

“I’m not really an orderly man. I rarely take notes and try to keep the things that are most important in mind.” Stereotyped thinking is not his thing. This restricts the view to the big picture. For him, illuminating topics from different perspectives and pointing out pros and cons in order to find the best solutions is an attitude towards life. On this basis, he is responsible for the major lines of research at both the Helmholtz Institute Münster, a Jülich branch office, and the “Münster Electrochemical Energy Technology” institute (MEET). His most important and faithful companion besides his keen mind: his gut feeling.

“The neighbour was the one who set the wheels in motion: he was a die-hard food chemist and inspired the teenage Martin Winter so much for food chemistry. In June 2019, the University of Münster (WWU). The scientific director of WWU’s “MEET” battery research centre, founded in 2009, teaches physical chemistry. Today, he is responsible for the major lines of research at both the Helmholtz Institute Münster, a Jülich branch office, and the “Münster Electrochemical Energy Technology” institute (MEET). His most important and faithful companion besides his keen mind: his gut feeling. “There are situations in which I have gathered all the facts, but still can’t get any further. My gut feeling is crucial then.”

“In 90 per cent of the cases he had been right. “I’m annoyed about the other ten per cent!”

The combination of gut feeling and knowledge contributed to the fact that Winter already had a good nose in the 1990s and relied on electrochemical energy storage and energy conversion. After graduating in food chemistry, he studied general chemistry and dealt with lithium-ion batteries (LIB) in his diploma thesis and doctorate. He negotiated problems that others could not solve before, his professional career picked up speed – similarly to the success story of the “magic battery”: it developed from a handmade rechargeable battery to a production-ready battery to the market leader in battery technology. Winter has contributed to this success story. “As the founder of modern lithium-ion chemistry, I see myself at the forefront – as far as electrolytes and anode materials are concerned, and also with our systemic approach that the materials are not considered individually, but in interaction,” explains the professor of physical chemistry. Today, in Germany and across the globe, he is the face of many of these topics.

OPENNESS DESIRED
Critics accuse Winter of still relying on a technology whose potential has been exhausted. Winter sees that differently: for him, there is still a need for research and development, for example to increase the energy density and capacity of the LIB. Nevertheless, it is important to be open to other approaches. “This ‘either/or perspective’ misses the point and restricts us in the overall view. Depending on the application, we will need various battery systems in the future. That’s why we should explore new things and make existing things better, safer and cheaper,” says Winter. He adds that “I would also like colleagues in the battery scene to be as open as we are in the technology debate.”

Only with openness will it be possible to jointly establish a national battery cell production that appears in every pie chart for battery cell production and does not disappear under the heading “other”, according to Winter: “At the end of my career, people should be able to say that battery research in general has benefited from our commitment – in terms of the fact that we have built a national community and that we have done a lot for society – also with regard to retaining and strengthening the country’s economic power and innovative capacity.”

KATJA LIERS

Many honours: numerous certificates and awards adorn the walls of Martin Winter’s office.

About Martin Winter
Martin Winter, born in 1965, is the founding director of the Helmholtz Institute Münster (HI MS), a branch of Forschungszentrum Jülich. The HI MS comprises three partners: in addition to Forschungszentrum Jülich, these are RWTH Aachen University and the University of Münster (WWU). The scientific director of WWU’s “MEET” battery research centre, founded in 2009, teaches physical chemistry. In June 2019, the Federal Ministry of Education and Research announced that it had chosen Münster as the location for the planned research facility for battery cell production. Winter had been instrumental in preparing the application.
What are you researching right now, Ms Ripoll?

“Right now, I’m investigating Janus particles – tiny particles that have two ‘faces’ like the Roman god Janus. The particles combine different properties. One example: the reaction to heat. If a liquid containing such particles is irradiated with laser light, one half of a particle heats up, the other half sets the particle in motion. In addition, the heated halves influence the neighbouring particles. Besides that, vortices and currents are created. Everything taken together changes the properties of the liquid. Such micromotors could be used to specifically control the behaviour of liquids and thus develop intelligent materials.”
We do it regularly without thinking about it: giving somebody a hug. We know intuitively when the time is right, how long the embrace should last and how close we can get to each other, whether we are comforting the other or just being friendly. “During a hug, we constantly send and receive non-verbal signals via eye contact, facial expression and the distance to the other person. This takes place without thinking – like a continuous, invisible data stream in the background,” explains Kai Vogeley. The professor of psychiatry and psychotherapy heads the special outpatient clinic “Autismus im Erwachsenenalter” (Adult Autism) at the University Hospital of Cologne and the study group “Social Cognition” at the Institute of Neuroscience and Medicine (INM-3).

People with autism find it difficult to perceive this “invisible data stream”, to interpret the feelings of their fellow human beings and to react appropriately. A hug makes them anxious and often causes stress and discomfort. This does not mean that the person has no feelings, however, but that it is very difficult for him or her to identify and communicate them. People with autism cannot decipher nonverbal communication messages. This can perhaps be compared to a text of which we are only allowed to read every tenth line. The content would probably not be accessible to anyone. No wonder, then, that there came a day in the office when a person with autism stood before Vogeley and asked him for instructions on how to hug. “Since then, I’ve seen hugs from a new perspective. It’s like a complicated grammar,” says Vogeley.

UNCLEAR CAUSES

An estimated 1 per cent of people worldwide live with autism. Accordingly, 800,000 women and men are affected in Germany alone. The exact causes of autism are still unclear. It is agreed in research that there is no universal cause for autism and that hereditary factors play a crucial role. “But it remains unclear which and how many genes are responsible,” says Vogeley. Some scientists assume 100 genes to be involved, others thousands – the human genome comprises 25,000 genes.

The diagnostic manual of the World Health Organization (WHO), the International Classification of Disease (ICD), defines autism as “a pervasive developmental disorder”. These include forms such as childhood autism, atypical autism and Asperger syndrome. In Germany, statutory health insurance physicians are obliged to make their diagnoses according to the ICD classifications. The term “autism” comes from the Greek word “autos”, which means “self” or “pertaining to oneself”.

The term

The term “autism” comes from the Greek word “autos”, which means “self” or “pertaining to oneself”.

The history

In 1943, an American by the name of Leo Kanner (pictured) was the first to describe the symptom of childhood autism as a subgroup within childhood schizophrenia. The autistic children he examined fended off any contact, did not speak or only in a peculiar way and were extremely concerned with the sameness of their environment. Kanner’s diagnostic criteria for determining this unusual behavioural disorder are still of importance today. Independently of Kanner, the Viennese paediatrician Hans Asperger simultaneously described a similar phenotype and called it autistic psychopathy.

The subject of autism makes feelings run high: some see it as a serious illness, others simply as being different. Kai Vogeley understands both perspectives. The psychiatrist has been addressing the subject for years – at Jülich as a researcher and at the University Hospital of Cologne both as a doctor and as director of the outpatient clinic “Autismus im Erwachsenenalter” (Adult Autism).
Among the people with autism who come to me are those who lead successful lives. So it’s hard for me as a doctor to call these people ill,” says Vogeley. Not everyone needs help. “These people urgently need support,” as Vogeley sums up. And then there are also those who come to see the doctor hoping that the diagnosis of autism could explain their peculiar behaviour. “But: someone who only develops peculiarities at the age of 15 or 16 may need help, but does not have a profound developmental disorder;” the researcher puts it straight. He diagnoses autism in only about one third of his patients. Therefore, the doctor has already met people who have complained that they did not get the diagnosis.

Vogeley and his Jülich study group are investigating the extent to which non-verbal communication has a measurable influence on brain activity. For example, the scientists have conducted a study on the “social look”: how do people with and without autism interpret the gaze of a counterpart? A virtual character was used that communicates using neither speech nor body language, but simply looks at the test person. Only the gazing time of the virtual character was changed – up to a maximum of four seconds.

“We were able to show that in people without autism, the sympathy for their artificial counterpart increased with the duration of the gaze,” says Vogeley. In them, the “social brain” is activated, that is, those brain areas that are responsible for experiencing compassion and social interaction. The imaging method of functional magnetic resonance imaging (fMRI) was used to record brain activity. “In people with autism, on the other hand, the measurement curve in the ‘social brain’ regions remained flat. The lack of response can be interpreted as a neurobiological indicator that the people affected find it harder to intuitively interpret the feelings and intentions of others,” explains Vogeley.

In addition, the so-called social motivation of people with autism may be reduced. “This would mean that people with autism might find social contact less interesting and less amusing or entertaining. However, this is only a guess so far,” the scientist emphasises.

The people at Jülich are also interested in the gender distribution in the diagnosis of autism: are more boys or girls affected? In children with Asperger syndrome – that is, autism in which those affected have an IQ higher than 70 – there are up to ten boys per girl, while in adults there are only about two men per woman. Genetics cannot explain this phenomenon. “At the moment, we’re assuming that girls are underdiagnosed. Obviously, they’re better at adapting and at attracting less attention,” explains Vogeley. “Camouflage” is the technical term. The study results of the Jülich researchers also confirm this.

CURABLE OR NOT?

According to current understanding, autism cannot be cured. Therapeutic and educational encouragement and support, however, help to achieve positive changes. For example, Dr. Jürgen Dukart from JLM-7, another section at the Institute of Neuroscience and Medicine, and colleagues from Switzerland, the Netherlands and Great Britain have discovered certain repetitive activity patterns in the brain that only occur in people with autism. This consistent pattern of so-called functional connectivity could be used in the long term as a biomarker for future therapies.

The idea: in the future, physicians could use medicines to shift the brain pattern towards a “healthy” pattern, thus improving the state of health. “The results of the study, which includes more than 800 autistic patients in four cohorts, could contribute to optimising existing forms of therapy or to finding new treatment options,” sums up Dukart. Even if there are many people with autism who are critical of research and believe that they are different indeed, but healthy nonetheless, science must not lose sight of those people who cannot cope with autism in their lives.

But from his many years of experience in the outpatient clinic, which has existed since 2005, the psychiatrist knows that the truth is unique for each person: “Among the people with autism who come to me are those who lead successful lives: teachers, nurses, psychologists, insurance brokers. Although they notice that they react differently from their fellow human beings in certain situations, they can handle it well and only need a diagnosis in order to be able to make things clear to themselves,” says the doctor. These people have both feet on the ground and have found a way for themselves and their environment to handle their ways of thinking and living. "So it's hard for me as a doctor to call these people ill," says Vogeley.

It is different with those who tell him that they are not well, cannot cope with everyday life, have no friends and can no longer go to work. According to Vogeley, 40 to 50 per cent of autistic people suffer from depression. They know that they think and feel differently and are persistently working on themselves in order to meet the common social expectations and to function properly – often with enormous effort and often in vain.

Read more about the topic of autism in the effzett online edition: effzett@-juelich.de/en
Climate neutrality clearly calculated

In order to achieve its climate protection targets by 2050, Germany must comprehensively restructure its energy system. How can this be realised at the lowest possible cost? Moreover, will the government’s current climate protection package achieve this goal? Jülich scientists have developed a whole range of computer models to answer these questions.

The task

Using computer models, researchers from the Institute of Energy and Climate Research (IEK-3) simulated the reorganisation of the German energy system. Their goal was to calculate the economically most advantageous road up to the year 2050 step by step, starting from the current situation. In the study, they had considered two different emission targets: a 95 per cent reduction in greenhouse gases and an 80 per cent reduction. Only the 95 per cent scenario corresponds approximately to the climate neutrality that the EU is striving for, so it is the results of these calculations that will be presented below.

The assumptions

• The German economy will grow continuously by 1.2 per cent per year until 2050.
• The number of inhabitants in Germany will decrease slightly to 76.6 million. Nevertheless, the number of households will rise due to the continuous trend towards smaller households.
• In accordance with the recommendations of the national commission on coal, Germany will phase out the generation of electricity from coal by 2038.
• Germany will phase out nuclear energy by 2022.
• Until 2030, the electricity grids will be expanded according to the plans of the Federal Network Agency.
• No carbon dioxide (CO2) will be stored in underground deposits.

Major results

EXPECTED COSTS

The most cost-effective way to achieve a 95 per cent reduction in German CO2 emissions by 2050 will cost Germany a total of €1,850 billion over a period of 30 years. In the process, annual costs will rise from around €9 billion in 2030 to €71 billion in 2040 and €128 billion in 2050. These are undoubtedly substantial amounts. However, the economic burden is not as high as one might expect, but is in the ballpark of today’s expenditure on energy supply. In 2018, Germany spent €63 billion on energy imports, which was equivalent to 1.9 per cent of gross domestic product. The €128 billion in 2050 would correspond to 2.8 per cent of the expected gross domestic product.

ENERGY SOURCES

The backbone of future power generation will be wind power and photovoltaics. In 2050, German plants will each produce almost six times the amount of electricity they generate today. This means that Germany will have to build additional wind turbines with a capacity of 6.6 gigawatts and solar plants with 3.9 gigawatts every year until then. This is many times higher than the current expansion rates.

Biomass and biogas will cover a quarter of Germany’s energy requirement in 2050, mainly supplying heat for buildings and industrial processes. Dependence on energy imports will decrease considerably: while around 70 per cent of energy is imported today, the share will be 20 per cent in 2050.

ENERGY EFFICIENCY

In order to reduce CO2 emissions, it is essential to use energy more efficiently in all consumption sectors – buildings, transport, industry. Since electricity generation will still involve considerable CO2 emissions until 2035, it is particularly effective to take immediate energy-saving measures. For example, until 2035, Germany must double the previous speed of energy-efficient renovation of its existing buildings. Heat pumps will become the most important heating technology by 2050.
“There is no doubt that the energy transition will continue to involve high investments for a long time to come. However, the transformation costs are predictable and manageable, while subsequent adaptation costs to climate change are uncertain and are likely to be several times higher.”

MARTIN ROBINIUS, HEAD OF THE STUDY

ENERGY STORAGE

In order for Germany to have enough energy even during a so-called “cold Dunkelflaute” lasting for days – dark doldrums with high heating demand, no sun and no wind – it needs huge energy storage facilities. Underground cavities are suitable for this purpose, such as those in salt domes, in which hydrogen is stored and extracted. Underground gas storage facilities can also be converted for this purpose. Storage power plants, in which air is pumped into a cavity and compressed, have proven to be the cheapest way to react quickly to shorter fluctuations in energy production or consumption. When electricity is required, this air is used to drive turbines.

In 2050, almost 12 million tonnes of hydrogen will be needed annually. Half of this will come from domestic electrolysis production, foreign electrolysis sites will Germany the other half. In order to transport and distribute hydrogen in Germany cost-efficiently, pipelines need to be constructed.

THE COMPUTER MODELS

About a dozen scientists from the Jülich Institute of Energy and Climate Research (IEK-3) have designed a novel range of computer models. All modules from this range can be combined and are characterised by an exceptionally high level of temporal and spatial detail: for example, one of the models can analyse and predict how much renewable energy is available in Europe for each hour and for each longitude and latitude.

It accesses weather data from the past 37 years and takes into account, among other things, the regulations for the construction of new photovoltaic or wind power plants, such as their minimum distances from buildings. Another model maps the European extra-high voltage and high voltage grid on the basis of existing expansion plans, thus providing essential information on possible imports and exports of electricity.

The scientists have fed the data from all individual models into the central components of the model range, NESTOR (National Energy System Model with integrated SecTOR coupling). NESTOR maps the entire German energy supply across all consumption sectors, including costs, from the source of energy via all conceivable paths to the energy ultimately used. On the road to 2050 and the 95 per cent reduction target, NESTOR is looking for the technologically and economically best energy system for every moment. A new method also allows the uncertainty of future costs to be taken into account.

What do you make of the Federal Government’s current climate protection programme in the light of your study results?

Some of the measures in the package are heading in the right direction – including those that promote more efficient use of energy in buildings or in industry. Other measures, such as the proposed distance regulation of wind power plants, are not sufficient to achieve the required expansion of wind power plants, according to our analyses. Finally, there are also elements in the climate protection programme that contradict our findings, for instance regarding the future significance of biomass. This resource plays a crucial role in our models (cf. the results regarding energy sources). According to our calculations, the area under cultivation for biomass needs to be doubled. The climate protection programme, by contrast, does not envisage any expansion of the area to be cultivated for bioenergy.

You have also run an optimisation of the German energy system to achieve a reduction in greenhouse gas emissions of just 80 per cent by 2050. What’s the result?

The total additional cost incurred by 2050 would only be about one third of the cost for a 95 per cent reduction. However, the 80 per cent target will not be enough for Germany to comply with the Paris Agreement, which aims at limiting global warming to well below 2 °C. Regardless, Germany should decide at an early stage which target it is working towards, as the transformation of the energy system varies according to the target. For example, new gas-fired power plants and heating technologies are economically advantageous for the 80 per cent reduction in emissions, but they will not enable the 95 per cent target to be achieved. In the latter case, hydrogen technologies will be among the crucial factors.

Can we actually trust the energy cost predictions of the computer models?

We believe so, yes. Computer models can’t predict the future – a technology may emerge that doesn’t even exist today – but we know the current energy system. Our models can display interactions within it. What’s more, our computer models take technological learning curves into account: the higher the number of units produced, for example of an energy technology system, the lower the price per unit. We also analysed how much a result is affected if the input variables change. For instance, we varied the cost of expanding wind power plants or hydrogen pipelines, and surprisingly, this had little effect on the composition of the ideal energy system.

Further information about the study can be found under the QR code or in the effzett online edition:

effzett.juelich.de/en

Dr.-Ing. Martin Robinius is head of department at the Techno-Economic Systems Analysis (IEK-3) section of the Institute of Energy and Climate Research

FRANK FRICK ASKED THE QUESTIONS.
In navigation systems, algorithms calculate the shortest or fastest route to a destination.

On Google, Facebook and the like, algorithms provide us with customised search results, purchase recommendations and news based on our previous activities.

Algorithms help with online banking, for example monitoring money transfer and spotting the attempts to commit fraudulent transactions.

The Open Access Monitor

In the future, a freely accessible, web-based computer program is intended to register the entire publication system of German academic institutions. This Open Access Monitor links information from various existing databases, for example about an institution’s stock of journal or about which articles can only be read for a fee. The Open Access Monitor can be used to answer questions such as:

• In which journals have a scientific institution’s researchers published and what was proportion of open access publications?
• How much have research institutions paid for open access publications?
• What magazines does an institution subscribe to and how much does it pay for them?
• How often were the journals accessed?

The Federal Ministry of Education and Research (BMBF) and the Alliance of Science Organisations in Germany are funding the development of the monitor at least until mid-2020. Until then, a first official version will be released. A test version is already online.

“CONTINUED ON PAGE 30”
THUMBS UP

THREE QUESTIONS FOR

Dr. Bernhard Mittermaier
Head of the Jülich Central Library

Why has the changeover to open access already taken about 15 years?

First of all, science publishers are stonewalling: the large publishers assume that they earn less with open access. Small publishers even fear that they will not survive the changeover in accounting and technology. For the most part, publishers have not yet converted to open access for those journals that are particularly highly regarded and frequently cited in specialist circles. These are precisely the scientists’ preferred journals for publication – also serving to collect brownie points in reviews, on which the funding of their research depends. Indirectly, the scientists thus support the subscription model. Research funders, in turn, are reluctant to make their funding dependent on scientists publishing in open access journals. The most important reason: they do not want to curtail the freedom of science.

To what extent can the Open Access Monitor support the changeover?

The scientific institutions and the major publishing houses are currently negotiating the full changeover to open access. There are already agreements to this end with the publishing houses Wiley and Springer Nature. For the first time, our Open Access Monitor now offers the possibility to query in a simple way how many publications an institution has with a publisher and what the costs for subscribed issues and open access publications have been so far. This data forms the basis for contract negotiations and can facilitate the decision to join the contracts currently being negotiated. So far, hardly any research institution has such data.

Why not?

It is very costly to collect them. There are thousands of journals involved. One of the biggest difficulties is that the names of publishers and magazines are not standardised: for example, one single publisher has often innumerable designations in the various databases.

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THUMBS UP

SCIENCE VIDEOS

“Quarks” explains everyday questions

“That’s why you can smell the rain,” “This is what happens to a spider when you vacuum it up” or “How microalgae can generate energy” – in short videos, the social media channels of the “Quarks” knowledge editorial team of WDR (the German public broadcasting institution of North Rhine-Westaphalia) offer answers to questions we encounter in everyday life. The animations with catchy statements are supplemented by background text on the “Quarks” website. A special eye-catcher: the Instagram account @beautyquarks.

It shows breathtakingly beautiful pictures of animals and nature.

– WWW.QUARKS.DE –

DIGITAL SCIENCE GAME

Win with CO₂

Climate protection and the reduction of global warming are currently on the minds of many. The new CO₂ pricing for transport and heating from 2021 is at the heart of the climate protection programme adopted by the German government. But what is the significance of the greenhouse gas carbon dioxide? As early as 2018, Project Management Jülich has designed the game “Gewinn mit CO₂” (Win with CO2) on behalf of the Federal Ministry of Education and Research (BMBF). Quiz questions or puzzles have to be solved to learn more and more about the history, benefits and consumption of CO₂.

– WWW.PTJ.DE/PROJEKTFOERDERUNG/FONA/CO2-WISSENSCHAFTSSPIEL –

TWITTER ACCOUNT

Researchers’ reality

Finding forgotten cities or mixing colourful chemicals – the life of a scientist often sounds exciting. The German-language Twitter account @realsci_DE shows that science doesn’t always steam and pop, however. In weekly rotation, “real” scientists invite the Twitter community into their everyday lives. No less exciting are their explanations as to what it really means to be a researcher. You can also scroll to find Forschungszentrum Jülich in the account timeline: in October 2019, Dr. Claudia Frick from the Jülich Central Library took over, and, in November, it was Dr. Sofie Valk from the Jülich Institute of Neuroscience and Medicine, section Brain and Behaviour (INM-7).

– TWITTER.COM/REALSCI_DE –
The fascinating brains exhibition

“Faszination Gehirn” will be on display in the German Bundestag in Berlin until 19 December 2019. Afterwards, it will be open to the public in the Düsseldorf Landtag from 14 to 30 January 2020. In addition to images and films about the brain, exhibits on current developments in medicine, computing, artificial intelligence and neurorobotics will be shown. Everybody who is interested must register for visiting the Bundestag. bit.ly/34fDV6e

“Room for the brain: in the lobby of the German Bundestag, an exhibition shows spectacular pictures and exhibits from brain research #HumanBrainProj.”