Portal Wissen

The Research Magazine of the University of Potsdam

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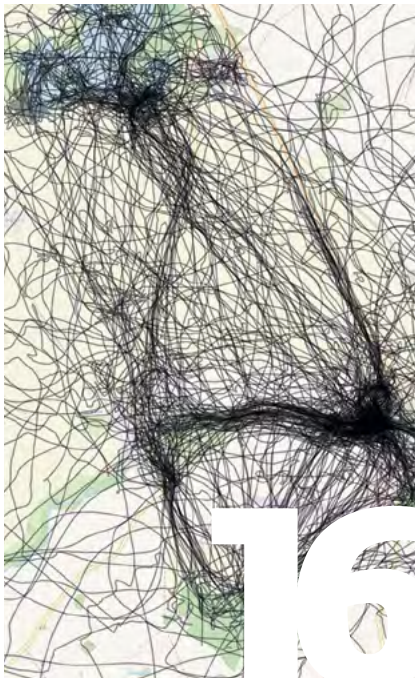
Universität Potsdam

EXCELLENCE



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EXCELLENCE

When something is not just good or very good, we often call it excellent. But what does that really mean? Coming from the Latin word "excellere," it describes things, persons, or actions that are outstanding or superior and distinguish themselves from others. It cannot get any better. Excellence is the top choice for being the first or the best. Research is no exception.

At the university, you will find numerous exceptional researchers, outstanding projects, and, time and again, sensational findings, publications, and results. But is the University of Potsdam also excellent? A question that will certainly create a different stir in 2023 than it did perhaps 20 years ago. Since the launch of the Excellence Initiative in 2005, universities that succeed in winning the most comprehensive funding program for research in Germany have been considered – literally – excellent. Whether in the form of graduate schools, research clusters, or – since the program was continued in 2019 under the title "Excellence Strategy" – entire universities of excellence: Anyone who wants to be among the best research universities needs the seal of excellence.

The University of Potsdam is applying for funding with three cluster proposals in the recently launched new round of the "Excellence Strategy of the German Federal and State Governments." One proposal comes from ecology and biodiversity research. The aim is to paint a comprehensive picture of ecological processes by examining the role of single individuals as well as the interactions among many species in an ecosystem to precisely determine the function of biodiversity. A second proposal has been submitted by the cognitive sciences. Here, the complex coexistence of language and cognition, development and learning, as well as motivation and behavior will be researched as a dynamic interrelation. The projects will include cooperation with the educational sciences to constantly consider linked learning and educational processes. The third proposal from the geo and environmental sciences concentrates on extreme and particularly devastating natural hazards and processes such as floods and droughts. The researchers examine these extreme events, focusing on their interaction with society, to be able to better assess the risks and damages they might involve and to initiate timely measures in the future.

"All three proposals highlight the excellence of our performance," emphasizes University President Prof. Oliver Günther, Ph.D. "The outlines impressively document our commitment, existing research excellence, and the potential of the University of Potsdam as a whole. The fact that three powerful consortia have come together in different subject areas shows that we have taken a good step forward on our way to becoming one of the top German universities."

In this issue, we are looking at what is in and behind these proposals: We talked to the researchers who wrote them. We asked them about their plans in case their proposals are successful and they bring a cluster of excellence to the university. But we also looked at the research that has led to the proposals, has long shaped the university's profile, and earned it national and international recognition. We present a small selection of projects, methods, and researchers to illustrate why there really is excellent research in these proposals!

By the way, "excellence" is also not the end of the flagpole. After all, the adjective "excellent" even has a comparative and a superlative. With this in mind, I wish you the most excellent pleasure reading this issue!

MATTHIAS ZIMMERMANN

Illustration: Andreas Topfer

President of the University of Potsdam Prof. Oliver Günther

“Ambitious But Not Presumptuous”

President Oliver Günther about research excellence at the University of Potsdam

The University of Potsdam wants to establish itself in the top tier of international research universities. For this purpose, it has submitted three proposals in the upcoming round of the Excellence Strategy of the German Federal and State governments (ExStra). Matthias Zimmermann spoke with University President Prof. Oliver Günther, Ph.D., about the beginnings as a research university and the chances for clusters of excellence.

Photo: Karla Fritze

The University of Potsdam has earned a particularly good reputation as a research university in recent years. What do you think is the "secret" of this success?

There are many reasons for this success. I think that even in its early years, the University of Potsdam paid attention to developing strengths, for example, in administrative sciences, cognitive research, and climate and earth sciences. We have consistently continued to develop these core areas but have also been able to add others. An essential basis for this is our hiring strategy, which has enabled us to attract outstanding researchers to Potsdam. Thanks to our tenure-track program, this also includes younger researchers. We also promote the further development of the administrative structures that make excellent research possible. The fruits of these efforts can be seen in the third-party funding we have attracted and the particularly good placements we have achieved in important rankings such as the international THE ranking, in which we are ranked 22nd among young universities under 50 years worldwide. In Germany we are even number 1. An important consequence of this path is a healthy measure of self-confidence among the faculty. This is good, it did not exist in this form ten years ago. For a long time, we stood somewhat in the shadow of the region's non-university research institutions. Now, however, we see that we can keep up internationally – and that our connections to the non-university research institutions do not limit but, on the contrary, inspire us. This is now reflected in our three proposals for clusters of excellence.

You have been President of the University of Potsdam since 2012. What vision for research at the UP did you bring with you – and have you been able to implement it?

My vision was to bring the University of Potsdam up from the lower midfield of the research landscape into the group of the best 20–30 German universities. We have succeeded, as the THE ranking, for example, shows. If you look around, we are now also perceived accordingly. This would not have been possible without close collaboration between the faculty, postdocs and Ph.D. students, as well as the administrative staff. This advancement was an important goal for me, but I think we can rise even higher. We want to continue to build on our strengths and make them more visible. One or more clusters of excellence would be important for this, and they would be an impressive proof. But we also want to increase the number of collaborative research centers at the University of Potsdam.

You travel a lot and represent the University of Potsdam all over the world. In which disciplines is the UP perceived as particularly strong?

Our principal areas of research are also internationally well known. While we lack a School of Medicine and the classical engineering sciences, we still represent a remarkably diverse range of subjects. At the end of the day, the research areas that resonate with our partners around the world are always those that are also well positioned there. Sometimes it's the geosciences, sometimes the cognitive, biological, or life sciences. Technical universities often recognize our computer science and its applications. But the humanities are not to be neglected either. In India, I once turned on the TV and whom did I see? Our military historian Sönke Neitzel explaining World War II to the Indian audience. That, too, is an important part of the visibility of our research and demonstrates its scope.

In the previous round of the excellence strategy, it was not possible to get a cluster to Potsdam. In this round, three proposals were submitted by the UP at once. What has happened since 2018?

I think a university has to go through a maturing process after it is founded. That is not only evident in Potsdam. One cannot produce a top research university out of thin air in five years. Those German universities that were founded shortly after reunification are only now in a situation where they have the structures and the self-confidence to catch up with the top tier of research universities. This can also be seen in the proposals for clusters of excellence: In the first two rounds, many proposals from East German universities were not bad, but the track record was simply not there. Now we are entering the race with three proposals, all of which are, we believe, well-positioned. This is not a lack of appreciation for the previous generations but simply the result of steady development, strategic hirings, and better funding.

Where do you see the research university of Potsdam in five years?

I hope that we will have been successful with as many cluster proposals as possible and that the number of collaborative research centers will have increased as well. Five would be a respectable number for a university of our size. If we succeed, it is quite conceivable that in 10–20 years we will be among the top 10–15 German research universities. That is certainly ambitious but not presumptuous.

THE INTERVIEW WAS CONDUCTED BY MATTHIAS ZIMMERMANN. TRANSLATION: SUSANNE VOIGT

“That would be an accolade!”

Dr. Manja Schüle, Minister for Science, Research, and Culture of the Federal State of Brandenburg, hopes that Potsdam will succeed in the Excellence Strategy of the German Federal Government

Minister of Science
Dr. Manja Schüle

Photo: Karoline Wolf

The University of Potsdam will submit three applications for the next round of the Excellence Strategy of the German Federal and State Governments (ExStra). Matthias Zimmermann interviewed Dr. Manja Schüle, Brandenburg's Minister for Science, Research, and Culture, about the chances of success and prospects for the future.

You are an alumna of the University of Potsdam yourself. What has happened in academic research since your time at the university?

A lot. The University of Potsdam has built a distinctive profile for itself: outstanding and innovative in teaching, strong in research, well established internationally, and focused on the creative and diverse support of young researchers. As a former student of the social sciences, I am aware of the passionate debate culture at this, at my university, which has had a strong influence on me. I consider the profiling of the University of Potsdam in particular, with the research focuses Cognitive Sciences, Data-Centric Sciences, Earth and Environmental Systems, and Evolutionary Systems Biology, to be a milestone. This has clearly provided a boost to third-party funding, which has virtually doubled compared to my time at the university. It is particularly encouraging that there is a focus on funding from the German Research Foundation (DFG), which has a prominent position in terms of research policy. In addition, the university has taken on other important tasks for the federal state in recent years and successfully expanded them, for example in teacher training.

Why is this the right time for one or more excellence clusters in Potsdam? Is the University of Potsdam now "mature" enough?

Absolutely. On the one hand, the University of Potsdam can draw on its experience in the last round of the Excellence Strategy, in which we also supported it financially. On the other hand, during the recent successful negotiations with the federal government and the other states on continuing the Excellence Strategy, I vehemently advocated for explicitly small and medium-sized universities to be able to benefit more in the future, for example by forming alliances. I would say that the conditions are ideal for another go.

In the current THE Ranking, the University of Potsdam is among the 250 best universities worldwide. Among young universities under 50 years of existence, it is even number 1 in Germany. What do you think makes the research strength of the University of Potsdam so special?

First of all, I would like to warmly congratulate the University of Potsdam on this success! Unfortunately, rankings are only one indicator for identifying research strength. The best proof of the University of Potsdam's excellent research strength would be to bring one or more of the coveted clusters of excellence to Brandenburg in the upcoming ExStra round of calls for proposals – without question a major feat in view of the strong competition. And more successes at the DFG would complement this overall picture. Of course, we should not forget to perceive the university learning environment as an individual experience marked by scientific debate.

What would be the significance of one or more excellence clusters for the Potsdam research region and the state of Brandenburg?

That would be an accolade! Particularly because there is still an east-west divide in terms of excellence funding and thus the danger of a two-tier university landscape in the long term. This will hopefully change in the future with the continuation of the excellence strategy. If Potsdam and Brandenburg succeed in benefiting from the excellence funding in the future, that would make a real difference because of the finances, the strengthened profiling, strategic competences, and the better international visibility of the university.

Where do you see the University of Potsdam in five or ten years?

I would like to see a medium-sized top university that, in five to ten years, has succeeded in being even more visible internationally in individual disciplines. A university that skillfully uses the potentials of cooperation with Potsdam's top research institutes to contribute to mastering the major social challenges. And I would like to see a university that continues to be a leader in regionally important tasks, such as teacher training, beyond Brandenburg.

THE INTERVIEW WAS CONDUCTED BY
MATTHIAS ZIMMERMANN.
TRANSLATION: SUSANNE VOIGT

Illustration: Andreas Topfer

“We need a more complex picture of ecological processes”

Why a paradigm shift towards an individual-based ecology is necessary

The world is in crisis. But not only climate change is alarming researchers; the biodiversity crisis has also assumed threatening proportions. There are still an estimated ten million species of animals, plants, and fungi in the world. More than two million of them are in danger of extinction – although it is almost impossible to put a precise number on this. The majority of species have not yet been studied at all, and the complex ecological systems in which living creatures coexist are still poorly understood in many places. To change the latter, scholars doing ecology and biodiversity research in Potsdam want to initiate a paradigm shift – toward an individual-based ecology. Matthias Zimmermann spoke to macroecologist Prof. Dr. Damaris Zurell and conservation ecologist Prof. Dr. Florian Jeltsch about growing expertise, important networks, and the question what an eye for detail can contribute to the bigger picture.

In what ways is Potsdam’s ecology and biodiversity research unique?

Jeltsch: There are three main things: First, our specific focus on quantitative, process-oriented ecology. Several research groups at the Institute of Biochemistry and Biology have been working on a better understanding of complex ecological relationships for a long time. The consistent application of quantitative methods to the study of ecological mechanisms and processes especially distinguishes our work.

Zurell: In fact, quantitative research has steadily gained importance in Potsdam. In the process, ecological modeling has built up an excellent reputation over the past 20 years. I was able to observe this from a distance because I took my first steps as a researcher in Potsdam and came back to Potsdam in 2020. Over the past ten years, the quantitative component has also had a special twist – thanks to new and further developed sensor technologies such as GPS transmitters, camera systems and methods for the automated recording of biodiversity. The skillful linking of this experimental and empirical research with mathematical and computer-based process modeling has become a trademark.

MORE INFORMATION:

www.uni-potsdam.de/de/individuen-basierte-oekologie

Prof. Damaris Zurell
and Prof. Florian Jeltsch

Jeltsch: This combination, our second strength, allows us to generalize detailed empirical and experimental results and thus apply them to diverse (environmental) conditions and larger scales. For example, the Ecology and Ecosystem Modeling group is primarily researching the dynamics in aquatic communities and complex food webs. Led by Ursula Gaedke, the team of the DFG Priority Program "DynaTrait" investigates plankton and biofilms as empirical model systems in which numerous predator and prey species can mutually adapt. The combination of laboratory experiments and field data from Lake Constance with mathematical models allows the team to abstract the research results in order to derive general rules of interaction in ecosystems. Anja Linstädter's group investigates how biodiversity is affected by land-use change, climate change, and other human impacts, especially in agricultural landscapes. Here, too, quantifying, process-based studies – in this case of plant traits – form a focal point.

A research focus of my own group is the movement of organisms – a key mechanism that influences biodiversity through the distribution of genes, resources, individuals, and species in space and time. To do this, we use state-of-the-art sensory technologies such as GPS telemetry with internal accelerometers, which we combine with advanced statistical analyses and spatially explicit, individual-based modeling. This allows us to investigate the causes and consequences of changing movement patterns in dynamic, anthropogenic landscapes for wildlife populations and biodiversity dynamics, e.g. in the context of our graduate program "BioMove". Quantifying processes also plays a central role in Jana Eccard's and Damaris Zurell's groups.

And thirdly, Potsdam has a uniquely dense and diverse research landscape in biodiversity research ...

Zurell: This strong networking of Potsdam's research is also reflected in the diversity of the investigated systems. For example, we do not only look at diverse ecosystems individually, but link our findings with each other, for example from aquatic and terrestrial studies. Our research deals with cities as economic-social-ecological units as well as with changing agricultural landscapes, drylands, and aquatic communities. Our research subjects include microorganisms, plants, and wildlife populations alike. This networking is strengthened through the cooperation with the many non-university research institutions in the region, which have found their institutional framework in the Berlin-Brandenburg Institute for Advanced Biodiversity Research (BBIB).

Photo: Tobias Hopfgarten

What makes Potsdam's ecology and biodiversity research so successful?

Jeltsch: For a long time, ecological research focused, for the sake of simplicity, on populations consisting of identical individuals, i.e. based on mean values without considering individual differences and their distribution. This is no longer sufficient! Especially in light of challenges posed by global changes, we need a more accurate, partly more complex picture of ecological processes. Therefore, our research approach places individuals and their interactions at the center. We consider individual organisms as the smallest natural unit responding to environmental change. Only on this basis can we understand how changes scale up to the level of populations and species communities.

Zurell: Potsdam started establishing individual-based models as a strong theoretical tool early on. Ultimately, an entire population or community does not respond to environmental changes in the same way, but individuals respond, and the different responses of all individuals then result in the system response. Averaging approaches do not capture this well. By now, we are getting to the point where we can use individual-based approaches to develop predictive models and estimate future biodiversity trends.

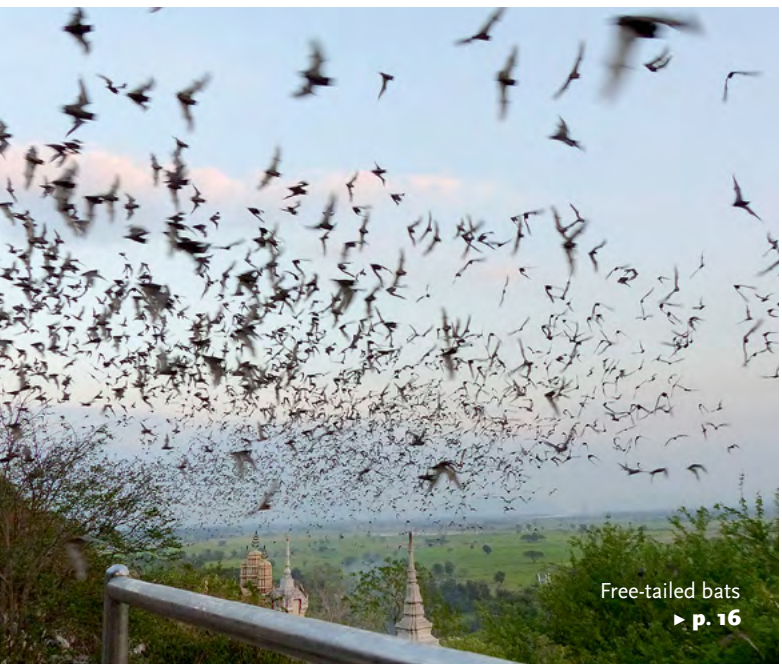
To do that, we need to understand many complex processes: How far north will certain species spread as a result of climate change, how will biotic interactions change as a result, and are native species able to respond quickly enough? How does human land use constrain animals and plants, and how do they interact with the changing environment? These questions are met with intense public debate because the consequences of climate change have become visible and tangible to many people. With a view to the future development of biodiversity and appropriate management strategies, our research can make a difference.

Jeltsch: In the Research Training Group "BioMove", for example, we study movement patterns of different species (e.g. bats, hares, wild boars, and various bird species) - and examine how they change as a result of land use, for example on agricultural land. These changes in movement patterns can in turn affect other species and ultimately have an impact at higher levels, such as the composition of species communities. Other projects, such as "DynaTrait," focus on the level of evolutionary traits of individuals. We see shifts away from mean-based approaches in many projects. For example, in cooperation with Bayer CropScience, we studied the effects of herbicides on non-target plants and developed individual-based grassland models for this purpose. With their help, we can then scale up the described herbicide effects and interactions between individual plants to entire grassland systems. This methodological approach has made us successful in recent years.

What role do special methodological approaches play?

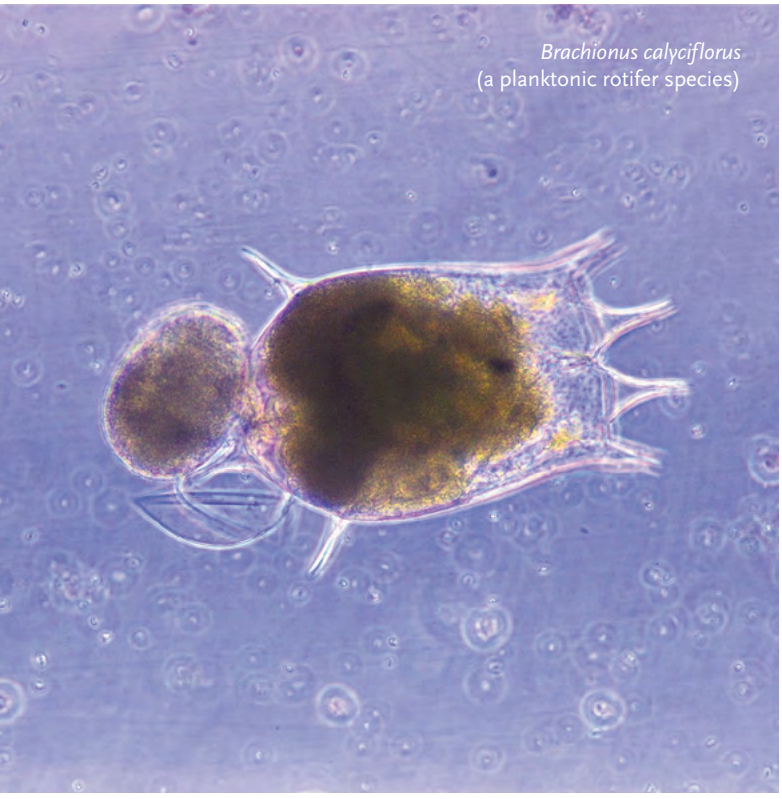
Zurell: Biodiversity and the processes that influence it are enormously complex. We need to look at species

Photos: Manuel Roeleke (left); Lars Erik Janner (right)



Free-tailed bats
▸ p. 16

European goldfinch at the Gülpe Ecological Station



Brachionus calyciflorus
(a planktonic rotifer species)

In the climatic exposure cabinet
of the "DynaTrait" project
▸ **p. 20**

A vole in the wild during
a behavioral experiment

or species communities, how their environment is changing, how individuals of different species interact with each other, and who has what capacities to adapt. To do this, we need to refine our approaches and be able to apply them in different places to understand similarities and distinctive features of different ecosystems. We need to examine details to understand when the variability of single individuals plays a crucial role and needs to be incorporated into the models for the whole system.

Jeltsch: Our approach of an ecological paradigm shift towards an individual-based ecology requires better, individualized data collection. Measuring processes at the level of interacting individuals is enormously costly but possible. For example, there are new methods to record animal movement, behavior, and even physiology with the help of transmitters. These are in use in some of our projects. Other (e.g. acoustic) sensors are also becoming more and more sophisticated and the evaluation methods increasingly precise. Sensors are not only used to study animals, however, but also to observe plants and their interactions. This is a field that is developing rapidly. Newly developed experiments on individual behavior, such as those used in the Eccard working group, are another example.

Zurell: However, to be able to successfully apply the findings of single individuals to large scales and contexts, we need data from a large number of individuals on the one hand and expertise in processing them correctly on the other. Bringing together hundreds of thousands of individuals and abiotic factors requires big data expertise. There is still a lot of work ahead of us, but we are on a good path.

Jeltsch: Researching the evolutionary side of biodiversity is also becoming increasingly important. We have long been moving in parallel on different time scales, looking at both short-term adaptation and longer periods. Therefore, we are glad to have an evolutionary biologist on board with Ralph Tiedemann. This is also true for the current joint appointments of Christian Voigt from the Institute of Zoo and Wildlife Research (IZW) and Lynn Govaert from the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), who both work at the interface of ecology and evolution. And, of course, we also rely on established, jointly appointed colleagues Hans-Peter Grossart from the IGB and Joerns Fickel from the IZW, who also conduct research at such important interfaces.

Zurell: One important question for ecological research is: On what scale do you conduct experiments?

Because in addition to the temporal dimension, the spatial one also plays a central role for us. For example, plant species in landscapes sometimes influence each other on a small scale, sometimes over long distances. To measure these connections, we have developed and established the ScapeLabs under the umbrella of the Berlin-Brandenburg Institute for Advanced Biodiversity Research (BBIB). These are experimental platforms in which we can extend biodiversity research to the ecosystem and landscape level, that is, from the single individual to the regional level. With the AgroScapeLabs, the CityScapeLabs, and the LakeScapeLabs, we have such multi-purpose landscape laboratories for agricultural areas, urban spaces, and freshwater systems. This is unique in ecological research. In my macroecology working group, we go beyond that and use observational data from around the world to understand universal relationships and special features.

What role does networking with other disciplines at the university or other non-university institutions play?

Zurell: The importance of networking for biodiversity research is illustrated, for example, by one remarkable fact: In 2022, the Intergovernmental Panel on Climate Change (IPCC) issued its sixth Assessment Report, while the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) just issued its first report in 2019. Biodiversity is extremely complex, and we are still in the early stages of becoming a discipline that can make predictions. There are some ten million species and 200 or more ecosystems in the world that have already suffered significant damage from global change. To protect them from further damage or to improve their condition, we need multidisciplinary knowledge and methodologies. This includes various fields of ecology, evolutionary research and microbiology, as well as data science. Artificial intelligence, for example, can not only help with data acquisition and analysis, but can also be used in decision-making tools, e.g. to optimize management strategies.

Jeltsch: With the aforementioned Berlin-Brandenburg Institute for Advanced Biodiversity Research (BBIB), there has long been a platform of institutions conducting research on biodiversity in the region. The BBIB is our umbrella institution, a consortium of four universities and five non-university research institutions that helps us to bundle existing competencies in the fields of ecological, evolutionary, social, and political sciences in the greater Berlin area. Major projects such as “DynaTrait”, “BioMove” or “BIBS - Bridging in Biodiversity Science” show that this is successful. The latter, as the name suggests, has already successfully built bridges between different disciplines to improve our understanding of biodiversity. I think it is one of the particular strengths of our region that professional networking in various constellations has been established and is working well. The numerous institutions with their different focus areas are helpful in this respect. There are joint appointments with many of them. These include the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI) with its focus on the Arctic and Antarctic, the Helmholtz Centre for Environmental Research (UFZ), where Volker Grimm conducts intensive research on ecological modeling, the Leibniz Institute of Agricultural Engineering and Bioeconomics (ATB) in Bornstedt and the Leibniz Centre for Agricultural Landscape Research (ZALF) in Müncheberg with their expertise on agricultural landscapes, the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), the German Entomological Institute Senckenberg in Müncheberg and the Leibniz Institute for Zoo and Wildlife Research (IZW). Together with the Berlin universities and the University of Potsdam, the network is extremely well positioned.

Hare with transmitter

Setting up gill nets in the AgroScapeLab Quillow to catch hares and fit them with GPS collars

▸ p. 19

Photos: Kidan Patanant (left); Wiebke Ullmann (right)

Zurell: Modeling has become increasingly important in recent years for the synthesizing the bigger picture and bringing together the large amounts of experimental data. This is also reflected in our networks. As far as the integration of data science is concerned, we are fortunate to have very good colleagues at the University of Potsdam, such as Ralf Metzler from theoretical physics, whose methodological expertise helps us a lot.

Potsdam's biodiversity research submitted an application for an excellence cluster in the next round of the excellence initiative. Why is Potsdam the right place for such an excellence cluster? And why now?

Jeltsch: With our many years of experience in individual-based ecology and in linking quantitative data with cross-scale modeling we are very well positioned for research into this field. In addition, our extensive network with its high density of research institutions guarantees a wide range of competencies and a broad spectrum of interdisciplinary topics. So, there is an enormous amount of experience and capacity here in terms of biodiversity research.

Namibia: Kudu being fitted with GPS collar.

Zurell: Why now? Because it is urgent! The biodiversity crisis is here, and we need to invest as much as we can, as quickly as possible, to better understand biodiversity change, enable predictions, and initiate a better management of human impacts on ecosystems. The methods exist, but they must be brought together. That's where we start – preferably with an excellence cluster.

How will you integrate and promote young researchers in the cluster?

Jeltsch: The "BioMove" Research Training Group, which has been working very successfully since 2016 and was extended in 2019, can serve as an excellent


Sensors for measuring transpiration are attached to mopane trees.


Gathering data for the NamTip project

Photos: Dr. Niels Blaum (left); Dr. Katja Geißler (top right); Vistorina Amputo (bottom right)

blueprint for us. It shows the innovative strength that young researchers bring with them. In this respect, I would say that such a group not only serves to teach young researchers, but that it brings an exchange with added value for both sides. And honestly, that starts at the bachelor's and master's level, where the engagement of the students is a tremendous asset to our research. They bring a creativity that you have to promote in every possible way. In that sense, it is up to us to create the necessary freedom and security so that young researchers are able to discover and create something. This is the basis for innovative research approaches, projects, and ideas.

Zurell: Such creativity is particularly important for us because biodiversity research is becoming more and more digital at an immense speed. Our individual-based agenda in particular is being enriched by new digital possibilities. Of course, it helps enormously that the younger generation of researchers and students are "digital natives" and can contribute impulses from a wide variety of fields. In this respect, there is once again the particular advantage of our location because we benefit from the quantitatively oriented training in our master's degree in Ecology, Evolution and Conservation with the statistical methods of movement ecology and a focus on modeling.

Jeltsch: The Potsdam Graduate School (PoGS), which has been supporting doctoral students from all disciplines for many years and has played a major role in the success of "BioMove", is also an important asset in the promotion of young researchers. We can build on this.

Zurell: The PoGS offers important individual programs related to research and teaching, but also beyond, such as mentoring or career counseling. And this doesn't just start with the PhD phase. In fact, quite a number of our master's students are already benefiting a lot from these programs.

How will the research results be communicated to the general public?

Jeltsch: Changes in biodiversity interest many people, even those who are not active in science. So our research will certainly be met with great interest! Fortunately, there are established showcases for this in Berlin and Brandenburg, such as the natural history museums in Berlin and Potsdam or the botanical gardens, with which we want to strengthen our cooperation. In addition, we are considering working with the Biosphere Potsdam to raise awareness for our topics among the public.

Zurell: Together with colleagues from digital education research, like Katharina Scheiter and Ulrike Lucke, we are also working on making not only our results but also the research itself tangible - for example with multimedia applications, apps, or games. In this way, we can, for example, bring ecological models that test what-if scenarios to life and visualize them. Digitization offers completely new opportunities not only for our research, but also for communicating it. We can show people how our environment is changing in the course of climate change. And we can bring concrete questions to life: What happens if we implement this or that measure? How can we support species? What does effective nature conservation look like? We have already gained initial experience with this at events such as the Potsdam Science Day - and we want to expand on this. In addition, our master's degree program integrates the results of our research into the training of young academics in the most direct way possible, which means a very effective transfer of knowledge.

Jeltsch: Last but not least, our findings ideally also find their way into political decision-making processes. Policy advice based on scientific expertise is an increasingly important field, as the Corona pandemic has shown. Formats such as the UN Conference on Biological Diversity COP 15, held in Montreal in December 2022, are important platforms for this. An excellence cluster would offer the ideal starting position for this.

THE INTERVIEW WAS CONDUCTED BY MATTHIAS ZIMMERMANN.
TRANSLATION: SUSANNE VOIGT

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Photos: Tobias Hopfgarten (2)

Movement profiles of common noctule bats, recorded with the automated telemetry system ATLAS

Photo: Dr. Manuel Roeleke

ATLAS

opens up entirely new possibilities for wildlife ecology

How the latest generation of modern tracking technology is advancing research

Humans have barely scratched the surface in understanding the world in which they live. Not only the flora but also the fauna of our earth continues to puzzle us in many respects. And yet, there is much we can learn from them. In order to better study and understand animal behavior, Potsdam ecologists have been working with a new system that bears the melodious name ATLAS. Matthias Zimmermann talked to Dr. Manuel Roeleke, who has already used this device successfully and has examined the "social streak" of bats.

ATLAS – What is it?

ATLAS stands for "Advanced Tracking and Localization of Animals in real-life Systems" and is an automated radio-tracking system developed by our partners, Prof. Dr. Sivan Toledo from Tel Aviv University and Prof. Dr. Ran Nathan from the Hebrew University of Jerusalem. ATLAS systems are used in Israel, the Netherlands, England, and by us in the Uckermark or Northeast Germany for automated tracking of animal movements. For this purpose, the animals have to be captured once and fitted with small radio transmitters.

What are the system's capabilities?

The system can simultaneously detect the movement of a large number of animals (approximately 150 or more) and with very accurate temporal and spatial resolution. This means that, depending on the programming, it tracks the tagged animals every 1-8 seconds with an accuracy of approximately five meters.

How does it work?

ATLAS uses a so-called reverse GPS technology. In conventional GPS tracking systems, animals are fitted with transmitters that receive signals from multiple satellites. Since the position of the satellites is known, the signal propagation delays can be used to determine the distance between the receiver and the satellite. Through trilateration, the GPS receiver can calculate the location of the animal.

The ATLAS system works the other way around, which provides some advantages. Several 15-meter-high receiving aerials are set up within the area to be studied. The animals get a transmitter whose signal is received by the aerials. Based on the different delay times, ATLAS uses the receivers to calculate the position of the animals. Currently, about ten receiving aerials are in operation, depending on the study, covering an area of about 100 square kilometers. The aerials are connected to a server at the University of Potsdam, which calculates the position within a few seconds, makes it available to the researchers, almost

Photo: privat

THE RESEARCHER

Dr. Manuel Roeleke studied biology in Ulm and Berlin. Since 2019, he has been a research assistant in the research group Plant Ecology and Nature Conservation at the University of Potsdam.

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ATLAS reception antennae

Jan Pufelski, the technician responsible for the ATLAS system, connects the components of an autonomous base station for use in the field.

in real time, and saves it to a database. Researchers from various institutions, such as the University of Potsdam and the Leibniz Institute for Zoo and Wildlife Research (IZW), from the "BioMove" graduate college have access to this data.

How does it differ from previous sensory methods?

As yet, individual animal movements have mainly been tracked using GPS trackers. These trackers are expensive and have to be programmed individually. They also require large batteries to receive and calculate the position, which makes them much heavier than radio transmitters. Not least, the position data is

Bats with transmitters

stored on the device, which is why the researchers either have to get the tracker back and thus must catch the animal again, or the GPS loggers have an additional transmitter unit that transmits the data. But this is again very energy intensive, resulting in bigger batteries, higher weight, and shorter runtime.

ATLAS transmitters, on the other hand, are much lighter because they are very energy-efficient. The smallest weigh only one gram. They send only a short ping every few seconds; data storage and position calculation take place centrally on the server at the UP. The smallest ATLAS transmitter runs for three weeks with a ping interval of eight seconds. This means that it can transmit over 200,000 positions, whereas a GPS tag of the same weight can only store around 100 positions, and then has to be retrieved to read out the data. The advantage of GPS devices is that they work worldwide, whereas the use of ATLAS is limited to a certain area. Thus, the use of GPS receiver-transmitter units is useful for heavy animals that have an extensive range of movement, or to track the migration of big animals. ATLAS, on the other hand, allows us to track small animals very accurately, much more cost-efficiently and with a higher resolution than with traditional GPS technology. The high degree of automation and low cost of the ATLAS system also make

Photos: Dr. Manuel Roeleke (3)

it suitable for observing large numbers of animals simultaneously. This allows us to better identify individual differences and interactions.

Where else do you use ATLAS at the University of Potsdam?

After a testing and development phase of one year, the first project started in 2018 with a system consisting of six receiving units at AgroScapeLabs in the Uckermark region. Since then, the system in the Uckermark has grown steadily and, depending on the study, we use ten to twelve receiving aerials – and this number is increasing. Our colleagues at ZALF support us in terms of infrastructure and logistics. Especially the good networking of ZALF in the region and the provision of the excellently equipped field station are of great importance. In addition, we receive invaluable support from farmers and private individuals in the region, who provide us with space and electricity to operate the receiving stations. By now, we are also able to operate stations independently with solar energy. We can move a mobile station within three hours if the corresponding installation areas are available. Plans are currently underway for additional independent systems in rural and urban areas.

So far, ATLAS has mainly been used in the context of the "BioMove" Research Training Group or in follow-up projects: In one of the first projects, we used it to track bats. Ongoing follow-up projects include research on information exchange in bats and the recording of ecosystem services. In total, about 150 bats have been tracked so far.

Additional projects are tracking different swallow species to investigate interactions and competition among species. A new "BioMove" project will monitor starlings to study the relationship between hunting behavior and breeding success. Other projects are looking at the interactions of different songbird species or the impact of invasive raccoons on ground-nesting birds. ATLAS opens up entirely new possibilities for wildlife ecology.

What insights have you already gained with ATLAS?

In the case of bats, we have been able to show that the animals are extremely flexible in their use of space and their hunting strategy. The long-term data show that the animals can adapt their use of hunting areas very quickly to the prey distribution within a year, but also between different years. When prey is hard to find, animals resort to social strategies to increase their hunting efficiency, while they hunt individually when prey is evenly distributed.

The initial data from Wiebke Ullmann's studies on songbirds indicate that barn swallows and House Martins partially overlap in their use of space. She will soon conduct a more detailed investigation to determine if they avoid competition by using different flight heights, and whether this strategy can be sustained even when the availability of food insects decreases.

THE INTERVIEW WAS CONDUCTED BY MATTHIAS ZIMMERMANN.
TRANSLATION: SUSANNE VOIGT

Photo: Carolin Scholz

The **"BioMove" Research Training Group** researches the impact of movement ecology on biodiversity in dynamic agricultural landscapes. For this purpose, the researchers are linking the research fields of biodiversity and movement ecology. "The ongoing intensification of land use is dramatically reducing the remaining areas that can serve as habitats for wildlife and plants," says Prof. Florian Jeltsch, spokesperson of the BioMove Research Training Group. These areas are important biodiversity hotspots in the landscape. However, the small size of the areas often leads to intensified interaction and displacement within existing species. "To understand the medium- and long-term consequences of different land-use options for the future of biodiversity, it is therefore important to better understand both the movement patterns of species in the modern agricultural landscape and the changing interactions among them."

https://bio-move.org/

↗ Article about „BioMove"

DiverSITy Provides STABILITY

In the Priority Program “DynaTrait”, biologists combine mathematical models, field studies, and laboratory experiments to explore how nature works

Photo: Tobias Hopfgarten

It is comfortably warm and bright in the climate chamber. At first glance, you don't see that the numerous glass flasks filling the illuminated shelves of the walk-in chamber are teeming with life. At a constant temperature of 20° C, various species of algae, rotifers, and water fleas are growing here. They are well cared for by the staff of the Ecology and Ecosystem Modelling Working Group. "The algae need a fresh medium with plenty of nutrients once or twice a week and the zooplankters are fed with algae," explains biologist Dr. Toni Klauschies, who works with these organisms.

There is a reason why they take good care of algae and zooplankton at the Institute of Biochemistry and Biology. They are important model organisms that represent the basis of natural food webs in waterbodies. With their help, researchers want to understand how different species live together in an ecosystem, how they support or inhibit each other, how they eat and are eaten, or how they reproduce. In the Priority Program "DynaTrait", funded by the German Research Foundation (DFG), they are primarily investigating the characteristics of organisms – the "traits" – which can be amazingly variable.

Symbiotic communities are constantly changing

Highly simplified, the food web in a natural lake looks like this: At the lowest level, microalgae, known as phytoplankton, convert solar energy into biomass through photosynthesis. The algae are the food source for the zooplankton, which include water fleas, rotifers, ciliates, and other animals, most of which are less than one millimeter in size. The zooplankton are eaten by small fish, which in turn are food for large fish.

However, such a food web is not a static but an extremely dynamic structure. Depending on the season, temperature, nutrient supply, and other environmental conditions, the density of organism fluctuates greatly, species compete with each other for resources and permanently adapt to the various environmental conditions. At each level of the food web, numerous species interact with each other, each with very different characteristics and capabilities. The algae and zooplankters in the climate chamber are only a small but very important component of the entire aquatic food web, which the researchers are using to study the mechanisms in such a complex system.

Dr. Klauschies points at a glass flask containing a somewhat turbid liquid. If you look at the contents of a drop of water taken from this flask under the microscope, there are lots of little dots scurrying around. If you look even more closely, you will recognize the rotifer Cephalodella: a tubular, transparent animal with a ciliated ring at the top, which is used to swirl food into its mouth. In a laboratory culture, Cephalodella leads a carefree life. It is regularly supplied with algae of just the right size and structure. In nature, things look quite different. Here, the rotifer must compete with other species for food, is itself prey to larger organisms and does not always have the perfect food available.

Under optimal conditions, this species exists in large numbers. When the conditions are not as good, the population size decreases. Dr. Klauschies takes a closer look at these cycles. He does this on the computer, where he uses mathematical models to replicate the population life cycles of different species, and also experimentally in the laboratory, where he tests how rotifer's growth rates develop at different temperatures, food sources, and in presence of a competitor.

Algae have defense strategies

"In classical ecological theory, it is assumed that organisms have fixed traits," explains group leader Prof. Dr. Ursula Gaedke. "But that's not the case, because individual species are not as rigid in their characteristics as is often assumed. Predators and prey adapt to each other." Some algae, for example, may develop long, spine-like appendages to avoid being eaten. If

THE RESEARCHERS

Prof. Dr. Ursula Gaedke studied biology at the University of Oldenburg and applied statistics at Oxford University. Since 1999, she has been Professor of Ecology and Ecosystem Modeling at the University of Potsdam. Since 2014, she has been head of the DFG priority program DynaTrait.

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Dr. Toni Klauschies studied biology and mathematics for the teaching profession at the University of Potsdam. Since 2016, he has been researching the coexistence of predator-prey systems and the influence of global changes on diverse communities in the project "DynaTrait".

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Photos: Tobias Hopfgarten (2)

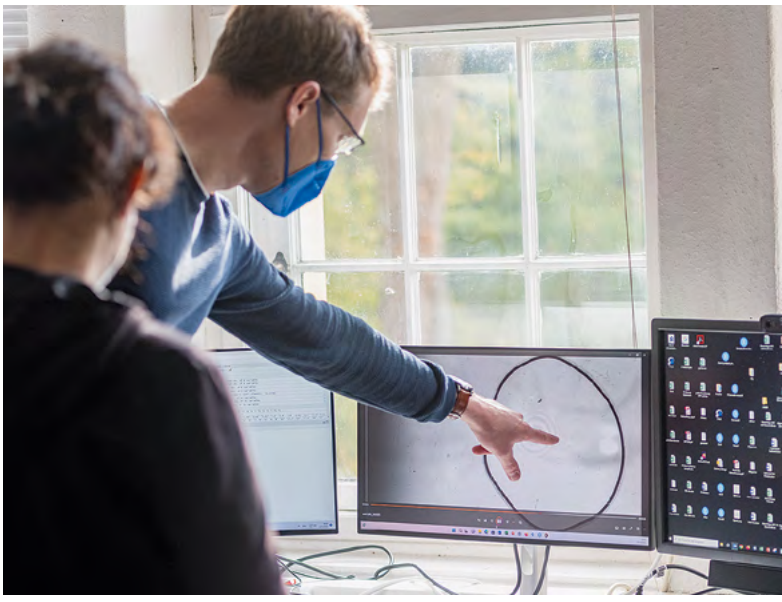
Dr. Toni Klauschies in the climate exposure cabinet

THE PROJECT

"DynaTrait" (Flexibility matters: Interplay between trait diversity and ecological dynamics using aquatic communities as model systems) is a priority program of the German Research Foundation (DFG). It investigates how the adaptive capacity of organisms affects food webs and ecosystem functions.

Participating: GEOMAR Helmholtz Centre for Ocean Research Kiel, Max Planck Institute for Evolutionary Biology, University of Potsdam, Carl von Ossietzky University of Oldenburg, Ruhr University Bochum, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Technische Universität Dresden, Helmholtz Center for Environmental Research, University of Konstanz, Osnabrück University, University of Cologne, Ludwig-Maximilians-Universität München, Alfred-Wegener Institute, Helmholtz Center for Polar and Marine Research, University of Duisburg-Essen, Helmholtz Center Hereon, Leibniz Center for Tropical marine research
Duration: 2014–2024

www.dynatrait.de



there are many zooplankton, such as rotifers that like eating these algae, they can still survive thanks to their defense mechanisms. However, the strategy comes at a price: Those that defend themselves with spines or other means reproduce more slowly and have fewer offspring. And predators also respond to their prey: They adjust their size to eat larger particles. Predators

Photos: Tobias Hopfgarten (2)

Prof. Ursula Gaedke

and prey are constantly upgrading and are sometimes very flexible in their strategies and traits. In the "DynaTrait" program, the researchers are tracking down these diverse adaptation mechanisms and want to find out how this flexibility affects ecosystem functions and population dynamics.

Since 2014, more than 60 scientists from all over Germany have been working on these questions in over 20 subprojects. They are evaluating long-term data from Lake Constance, cultivating different species of phytoplankton and zooplankton together in long laboratory experiments, determining growth rates of individual species under different conditions and modeling food webs and their individual building blocks on the computer. They exchange their results with each other and thus gradually approach an overall picture. "We find such an enormous diversity of species in nature. How does this actually happen? Why can so many species coexist with each other?" These are the fundamental questions behind the research projects, Prof. Gaedke explains.

How well an ecosystem can adapt to changing conditions or survive disturbances also depends on how many species are present. "Biodiversity leads to stability," she says, describing an important observation from the work so far, which will be examined in more detail in future research. If, for example, one or more species fail – due to disease, heat, or heavy rains that wash too many nutrients into water body –this can become a major problem for a species-poor system. Losses at the lower end of the food chain quickly spread to the upper levels. If there is less zooplankton, for example, fish will no longer find sufficient food. So, the problem also has an economic dimension.

In intact, diverse ecosystems, these strong fluctuations do not exist. If one species fails, another one better able to cope with the conditions immediately steps in. In the model simulation, the researchers compared how a very species-poor and a species-rich community of algae and zooplankton reacted to a strong nutrient input. While an algal bloom developed in the species-poor community, which can cause fish mortality and other problems in waters, these developments did not occur in the diverse community. Here, various zooplankton species were able to regulate the algae well and prevent mass proliferation.

Basic ecological questions are examined with model organisms

The researchers now want to verify individual results from the modeling under experimental conditions in the laboratory. The experiments will also show whether the mechanisms found in the model occur and are relevant in natural systems. Doing so, they are taking advantage of the fact that phytoplankton and zooplankton are very good model organisms that can be easily cultivated and quickly reproduced in the laboratory. They can be used to investigate fundamental ecological questions that can also be transferred to other ecosystems. The experiments will test, for example, whether changes in temperature influence the coexistence of organisms or how salt stress affects the growth of individual species. "What do population dynamics look like? Under what conditions can species coexist? And when do systems become unstable?" Dr. Klauschies wants to answer these questions with his experiments.

He knows from his own experience that it is not easy at all to recreate nature in the laboratory. If several species grow together in an experiment, individual species always disappear unintended. "In the lab, species compete more strongly. In nature, on the other hand, various mechanisms work together to enable coexistence," he explains. So, it takes a lot of intuition and patience to set up an experimental laboratory system with several species. However, Dr. Klauschies finds the close interlocking with the modeling just as important. "That helps a lot with going through other options that you can't reproduce in the lab."

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

Photo: Tobias Hopfgarten

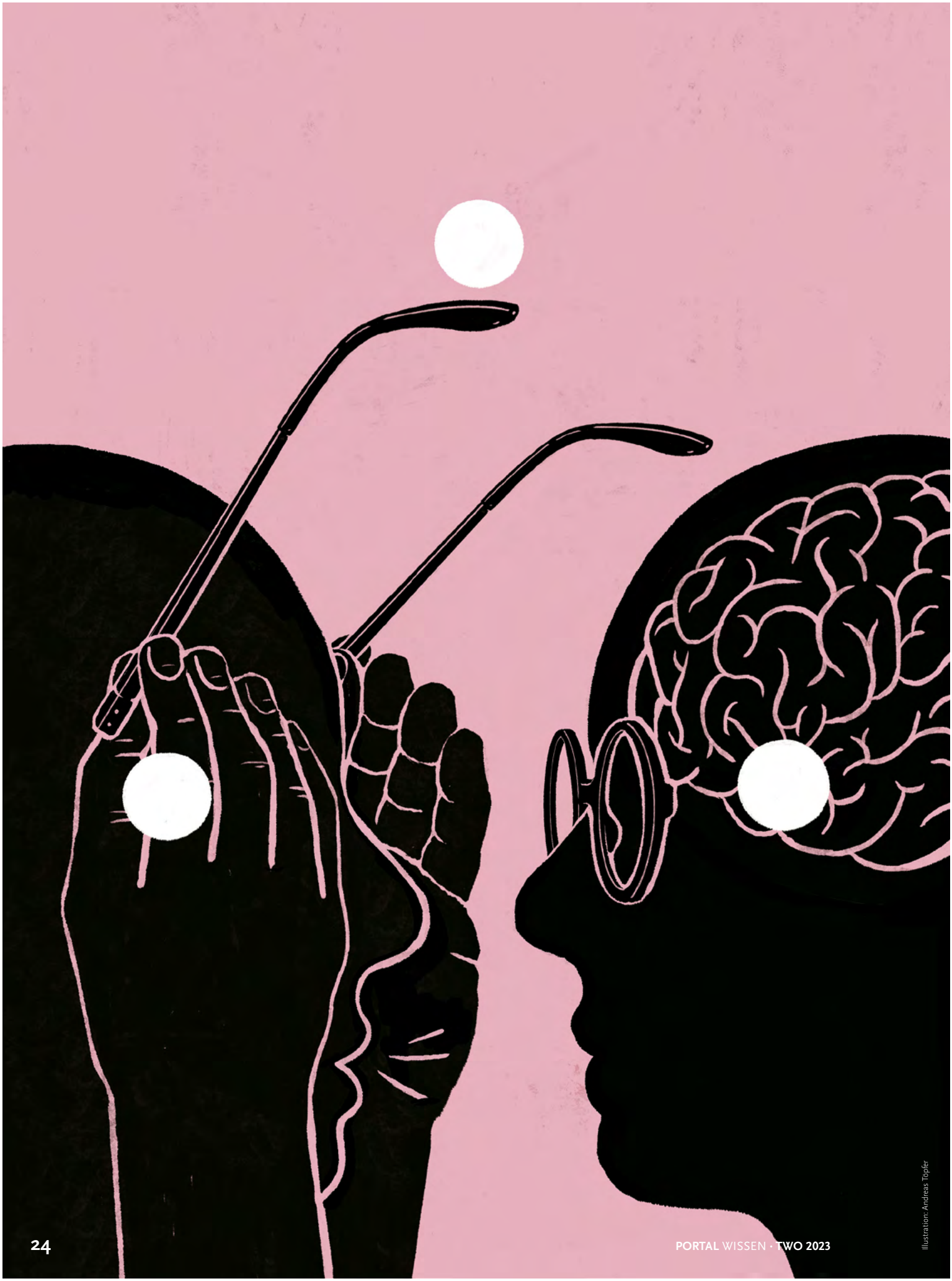


Illustration: Andreas Töpfer

“Now is the right time and this is the right place“

In Potsdam’s cognitive sciences, researchers from different disciplines have been working together successfully for many years

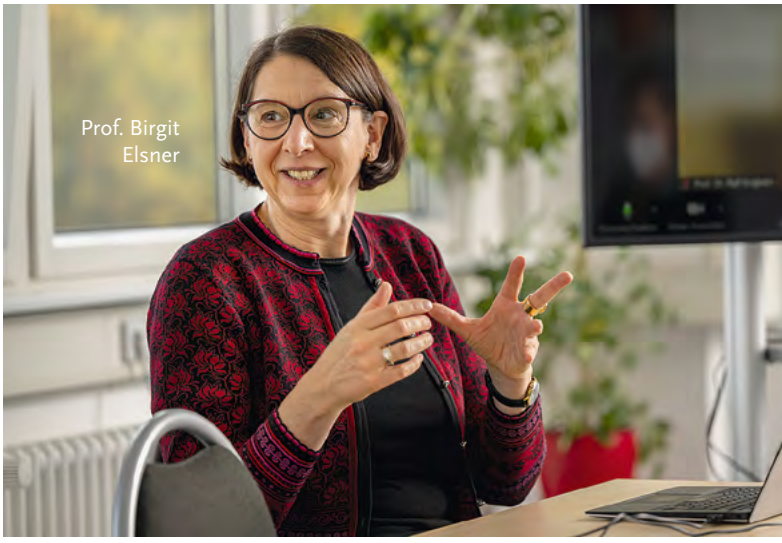
The cognitive sciences deal with the information processing and structures of an intelligent system – be it humans or machines. In Potsdam, cognitive sciences are an important research focus, with scientists from the Faculty of Human Sciences and the Faculty of Mathematics and Natural Sciences working closely together since the 1990s.Developmental psychologist Prof. Dr. Birgit Elsner, cognitive psychologist Prof. Dr. Ralf Engbert, and computational linguist Prof. Dr. David Schlangen compiled a draft proposal for a cluster of excellence in cognitive sciences at the University of Potsdam. In this interview, the researchers talk about what makes Potsdam’s cognitive sciences unique, why it is so important to understand information processing and human behavior as dynamic processes, and why now is the right time for a cluster of excellence.

What distinguishes Potsdam’s cognitive sciences?

Engbert: A specific feature is the fact that interdisciplinary research projects in cognitive science have existed since the University of Potsdam’s founding years. We can look back on long-term collaborations between psychology and linguistics on the one hand and mathematics, physics, and computer science on the other. As a result, we have developed a particularly good mutual understanding of the perspectives of other disciplines – which of course facilitates establishing new collaborative research initiatives. In addition, many connections and a lively exchange of methods have developed among the numerous laboratories in the different working groups. For example, it is certainly unusual that the BabyLAB has crossed the traditional divide between psychology and linguistics by studying parallels in the development of language and cognition. Finally, the cognitive sciences have developed exceptionally good research methods in their long-standing cooperation with the natural sciences. This becomes visible in initiatives such as the summer school “Statistical Methods for Linguistics and Psychology”, initiated by Prof. Shravan Vasishth, which draws international young researchers to Potsdam every year.

Elsner: This tradition in interdisciplinary research of the Potsdam cognitive sciences is indeed unique. It has resulted in many publications and large-scale

Prof. David Schlangen



Prof. Birgit Elsner

Prof. Ralf Engbert

interdisciplinary research projects, such as the Collaborative Research Center (SFB) 1287 "Limits of Variability in Language" in linguistics. There are also two projects in SFB 1294 "Data Assimilation" involving colleagues from psychology and linguistics.

Schlangen: In the cognitive sciences, a strategic appointment approach has been pursued for a long time: The aim is to organize the departments in such a way that interdisciplinary collaboration is and remains to be possible.

Engbert: A good team increases the chances of acquiring funding for larger research projects. And conversely, one should not underestimate the fact that a collaborative research center creates an extremely attractive environment for young researchers. Our strategy is a self-enhancing process because all of this contributes to research strength.

Elsner: Not least, the diversity of the applied methods is what makes Potsdam's cognitive sciences so successful.

THE RESEARCHERS

Prof. Dr. David Schlangen is Professor of the Foundations of Computational Linguistics and investigates verbal and non-verbal interactions between human and artificial agents, amongst other places at the computer-linguistics laboratory of the University of Potsdam.

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Prof. Dr. Birgit Elsner is Professor of Developmental Psychology. Together with Prof. Barbara Höhle, she heads the Potsdam BabyLAB, studying mental development and language acquisition in the first years of life.

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Prof. Dr. Ralf Engbert is Professor of Experimental and Biological Psychology at the University of Potsdam and an expert in dynamic cognitive systems for modelling cognitive processes and eye movement analysis in the EyeLab.

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Could you specify that a bit more? Which specific research methods, which laboratories characterize Potsdam?

Elsner: On the one hand, we have the traditional experiments to observe people's behavior. In the BabyLAB, for example, we use video recordings, and here and in other labs we use eye tracking to measure with pixel precision in the range of milliseconds how a per-

Photos: Thomas Roese (top left, top right); Tobias Hopfgarten (bottom left)

son's gaze moves across a screen. At the University of Potsdam, there are also laboratories that specialize in speech perception and production. They are able to record, for example, the muscular movements of the tongue during speech. In neurophysiological laboratories, we also record psychophysiological measures that can provide information about our mental states: for example, skin resistance, which can indicate whether someone is currently agitated. Finally, we can record brain activity with electroencephalograms (EEG).

In Potsdam, we also have experts for mathematical and computer modeling of cognitive processes. This broad repertoire of methods enables us to answer research questions about linguistic or non-linguistic cognition. Our researchers also share their expertise to initiate joint research projects.

Schlangen: Our computational linguistics lab, where we study interactions with humanoid robots, is extraordinary, too. In preparation for the cluster of excellence, we plan to use robots for experiments in psycholinguistics because they are very well suited as extremely controllable counterparts. Prof. Audrey Bürki from linguistics is currently building a driving simulator. She is studying how much cognitive capacity driving ties up and how that affects speech production. When it comes to eye tracking, Potsdam is at the top. When Reinhold Kliegl established eye movement research at the university, it was pioneering work in Germany. This has been continued by Ralf Engbert and other researchers. I believe that the variety of empirical methods available to us is a unique selling point of Potsdam.

Elsner: Eye tracking has long been used in Potsdam in reading research, but also beyond. In the BabyLAB, we use eye movement measurements to explore infants' thinking and language acquisition. This is an extremely helpful method because babies cannot express themselves verbally. We have to infer what is going on in their heads from their behavior.

Engbert: In reading research, we use eye tracking and eye-movement-dependent displays to study how readers process words. This allows us to check very precisely how far the cognitive processing of individual words has progressed. In this way, we learn a great deal about process models of eye movement control during reading. This knowledge can also be used in other areas.

Schlangen: In short, we can say that in Potsdam we have both the equipment and the experts who use it to collect high-quality data – both from behavior and physiological signals. When we measure how the hands move in three-dimensional space during movement tracking, or when we use an app to ask people about their current motivational state over an extended period of time, we obtain data with high temporal resolution - from milliseconds to days to years. The cluster of excellence has the aim to meet the challenge of using state-of-the-art mathematical and computational methods to form larger integrative models and thus explain the dynamics of cognition and behavior.

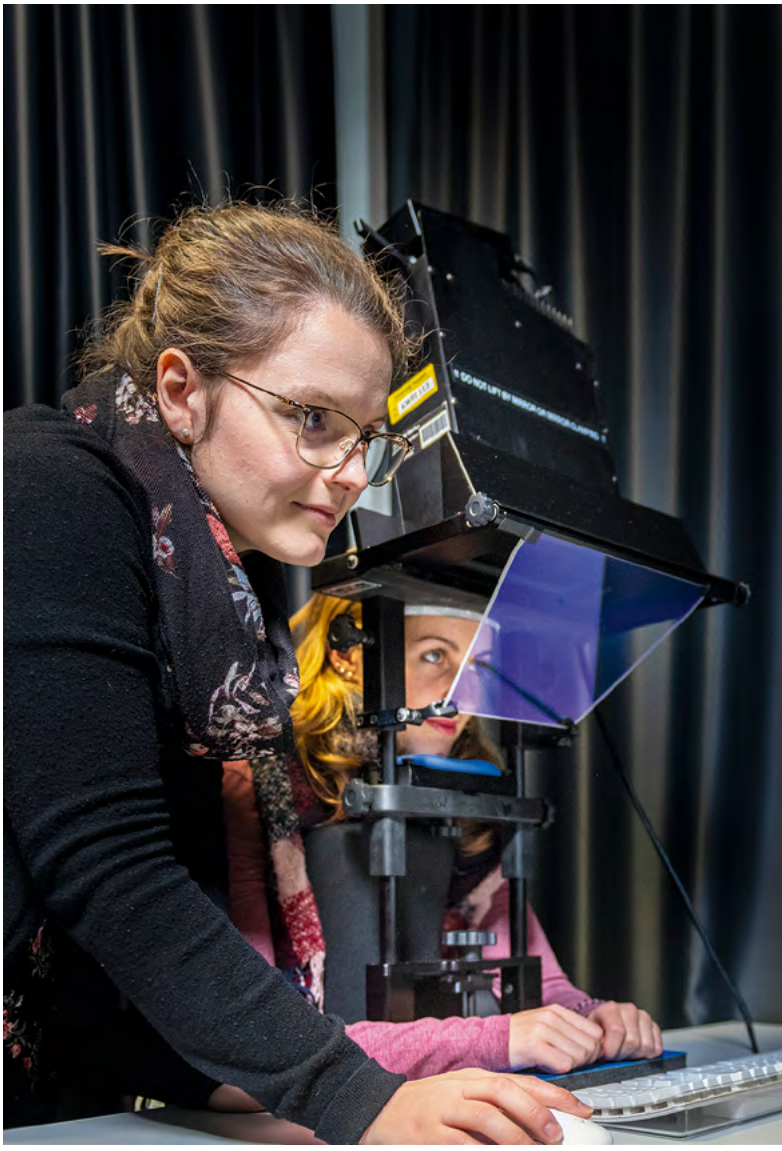
You mentioned the cluster of excellence for which you applied in the next round of the excellence initiative. What will be its focus?

Elsner: We are planning four research areas. First, there is "Language and Cognition" with the established longstanding research tradition in psychology and linguistics. Among other things, research here will examine how the processing and production of language is influenced by non-linguistic processes such as attention. In addition to the two SFBs, this is based on the DFG Research Group 2253 on the interplay of language and cognition in early human development, which also extends into the second area of "Development and Learning". The focus here is on dynamic changes in cognition, language, knowledge, and skills that emerge throughout the life course but also in short-term learning processes. In the third area, "Motivation and Behavior," colleagues from the sports and health sciences investigate the cognitive foundations of health-oriented behavior. For example, why it is often difficult to drink less alcohol or exercise more. At the same time, we want to strengthen cooperations with the educational sciences to look at the dynamics of learning and educational processes and find out how people acquire new skills.

Engbert: "Mathematical and computational modeling" is the fourth area. Statistical modeling has always been a strength of the cognitive sciences. In the last 20 - 30 years, we have also gained an increasing variety of process-oriented explanatory approaches. There are computational models that are more biologically motivated and those that are more based on cognitive theories. There are also approaches from mathematics and computer science, such as machine learning, which make few prior assumptions about cognitive processes. In the planned cluster of excellence, we

↗ More articles about Potsdam's cognitive sciences

Language experiment in a driving simulator



want to investigate what contribution can be made by the different modeling approaches.

What does that mean in detail? Which questions do you want to investigate in the cluster of excellence?

Elsner: Because cognitive processes are very dynamic, we need more research on the variation of behavior over time. An eye movement, for example, creates a data point every millisecond: In the BabyLAB, we measure at what time children look at a point on the screen that is important for our research question. Some babies' eyes arrive at this point after 100 milliseconds, but others' only later. Thus, we calculate a numerical value for each child that summarizes their gaze behavior – the data are "aggregated". But the course of movements would also be interesting: Where does the child's gaze start? And if the child takes longer, what other points might he or she have looked at? We can now collect such data with a high temporal resolution, but we also need appropriate evaluation methods. The goal of the cluster of excellence would be to investigate dynamic processes in cognition and behavior on different time scales, that is, in the millisecond range in which our thinking or eye movements take place, as well as over longer periods of time when it's about learning or the course of human development.

Engbert: Dynamical systems are one of the domains of mathematics and physics. We would like to use their modeling possibilities and bring them together with cognitive science research to obtain more precise explanations of why a process develops. For example, how do a person's different prior experiences affect how they process something cognitively? As far as language processing is concerned, several models are available that explain individual aspects of this process. What is missing are models that represent processing in all its complexity. I think it would be presumptuous to look for a theory that explains everything. But we at least want to see which of the existing models, or which combinations of models, are best suited to explain cognitive processes more holistically.

Schlangen: Machine speech processing is another vivid example of dynamic processes. Most models for today's dialog systems, whether as chatbots or voice assistants, assume that a spoken or written utterance must be completed before information processing can begin. So a voice assistant or humanoid robot waits

Photos: Sandra Scholz (left); Thomas Roese (right)

Eye-tracking experiment

Mobile eye-tracker in use

Photo: Thomas Roese

until a sentence, for example, is complete. This is extremely simplistic and unrealistic because human information processing, or cognition, operates continuously. Many of the existing models don't consider this time aspect, and we want to bring it back in. If we can model how language processing occurs bit by bit in time, it can improve the quality of interaction with artificial systems. For example, humanoid robots can exhibit behaviors such as nodding their heads while they are still listening rather than when we pause. But not only speaking, reading also takes place in time. After all, a longer sentence is not taken in all at once, but the eyes move over the individual words.

Elsner: Exactly, the brain takes in a text bit by bit, constantly referring to prior experience. I also don't have to read every word because I can anticipate certain verbal constructions. But of course, it also happens that such expectations are not met. That's why tracking these processes is so important.

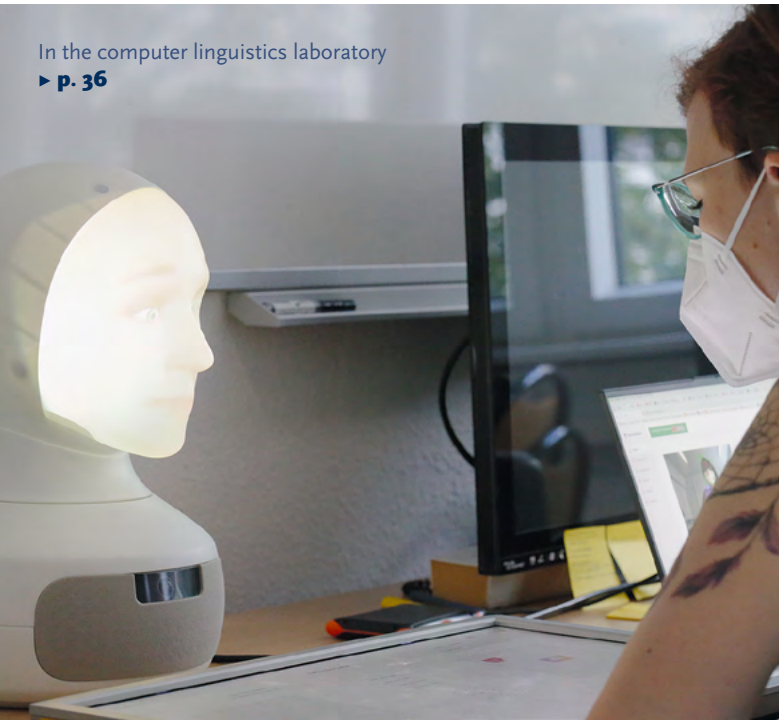
Why is Potsdam the right place for a cluster of excellence in the cognitive sciences?

Engbert: We have long interdisciplinary experience in researching various aspects of human information processing. Today, many colleagues at our university are working on structurally similar questions and are creating new cross-connections. This is promoted by similar measurement methods, some overlap in the research topics and the increasing availability of theoretical models. When you work together rather than side by side, you can learn a lot from each other.

Elsner: It is also important to note that the university's decision to promote the cognitive sciences as a research focus is now bearing fruit. This has received a lot of attention in Germany. The fact that the university has created supporting structures to push-start such major research initiatives is a key component.

Schlangen: The two collaborative research centers, which were recently extended into the second funding period, have shown that we can collaborate very successfully across disciplines. Now we can say with a lot of self-confidence: We also dare to apply for a cluster of excellence! The prerequisites are in place. The draft proposal is a natural next step, the logical consequence, so to speak.

Elsner: There are various substantive threads and structural conditions that only come together for what we have in mind at the University of Potsdam. That's why now is the right time and this is the right place.



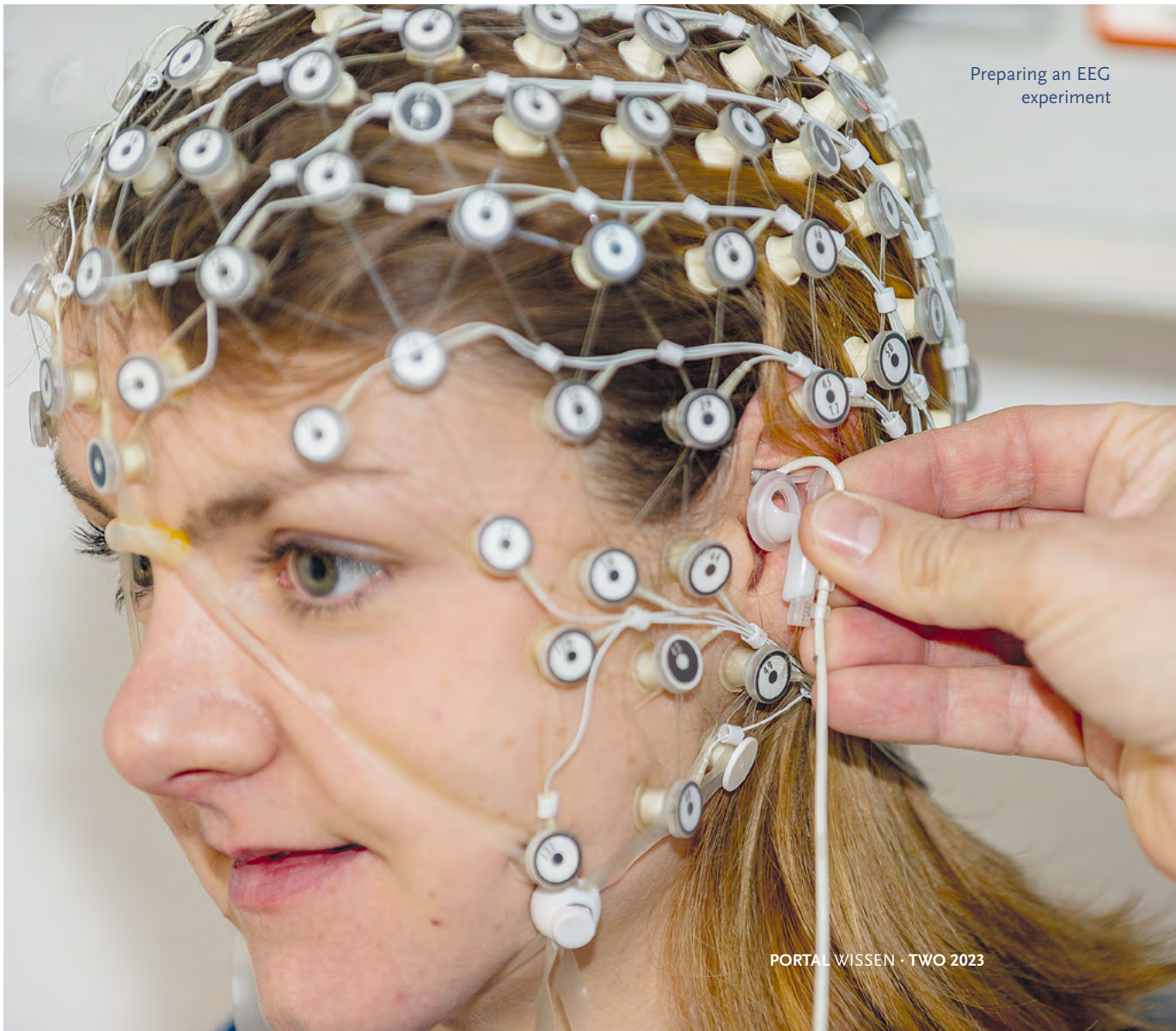
In the computer linguistics laboratory
▸ p. 36

How will you integrate and promote young researchers?

Schlangen: In addition to supporting PhD candidates and postdocs, we are planning junior research groups with a high degree of independence and a strong mentoring program. We have very well-functioning degree programs, such as the Bachelor “Cognitive Sciences” and the two international Masters “Cognitive Science - Embodied Cognition” and “Cognitive Systems”. We can offer research-oriented teaching and attract suitable candidates for doctoral positions and subsequently for postdoctoral positions. At the professorial level, the age structure was important to us, which is why we have also included younger colleagues.

Engbert: A major focus will be to introduce PhD candidates and postdocs to our innovative research methods and to train them in mathematical and computational modeling as well as in the combination of measurement methods, such as collecting data at different levels of behavior. We want to lead them to academic independence at an early stage while achieving

Photos: Sandra Scholz (top); Tobias Hopfgarten (bottom)



Preparing an EEG experiment

A young test subject ...

diversity at different levels. Gender balance is very good in psychology and linguistics, while modelling is still a field with more male than female scientists. In the cluster, we strive to bring together people of different genders, nationalities, social backgrounds, and physical abilities – not only at the level of project leaders, where we are already very well positioned, but also among researchers at other stages of their scientific careers.

Schlangen: We are planning to share our modeling approaches not only via summer schools, but also via Open Educational Resources for education and training at and outside the university.

Elsner: We would like to use apps or gaming tasks to let a broader public participate in our cognitive science research. These could motivate people to participate in studies and provide information about their emotions or aspects of their daily lives several times a day without having to travel to the lab. For our research on the dynamics of cognition and behavior, we need a lot of data points. We can get them reliably via laboratory studies and online methods. Our initiative is focused on basic research: We want to describe and explain how intelligent systems process information and produce behavior; how mental processes happen. This is also important for societal goals because learning and support programs or motivational aids for health-related behavior, for example, could be developed based on such findings.

THE INTERVIEW WAS CONDUCTED BY DR. JANA SCHOLZ. TRANSLATION: SUSANNE VOIGT

... in the BabyLAB

Photos: Tobias Hopfgarten (2)

Early Detection at the Push of a **Button**

Prof. Natalie Boll-Avetisyan has developed a toy to indicate the risk of a language disorder

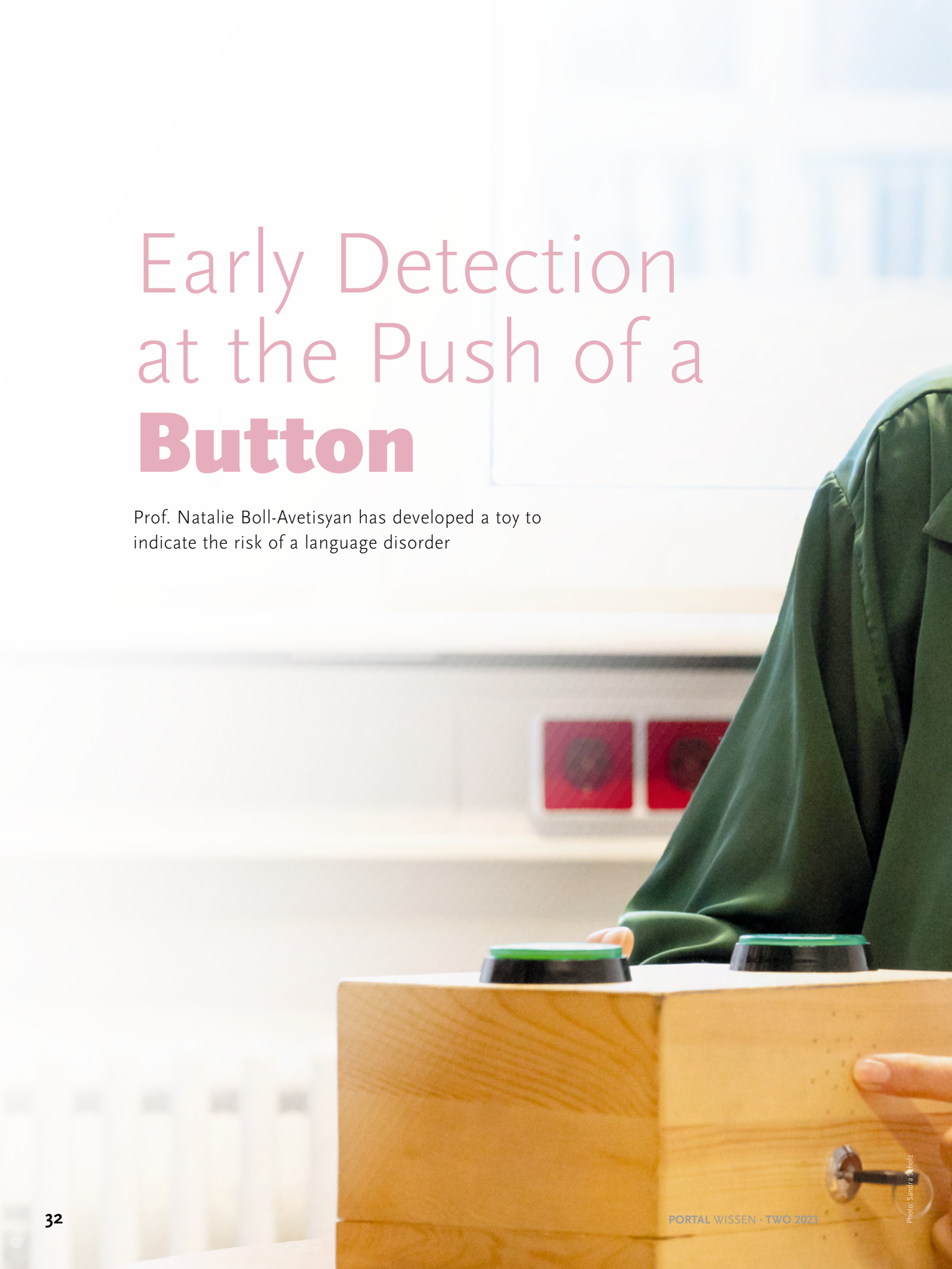


Photo: Sandra Scholz

↗ The detailed article

The teacher gives specific instructions: "When you have finished the exercise, pack the book, go to the shelf, and get a worksheet from the rack." The pupils follow without any difficulty. Only one boy packs his book and remains seated. Was he not listening properly? On the contrary, the instruction was simply too complex for him. He has a developmental language disorder that makes it difficult for him to understand what is being said. Such disorders are often only discovered when they become obvious in everyday life. That is too late for Natalie Boll-Avetisyan. With the help of a toy, the psycholinguist wants to make sure that such risks are already recognized in infants.

It sounds quite unusual: playing for science. But for the small test subjects whose behavior Boll-Avetisyan analyzes, it is exactly the right research method. "My method is suitable for babies from the age of nine months. From this age on, they can play with the toy," she explains. "You can test children very early to see if they have difficulties with language. Long-term studies from the field of language development research show that in the case of disorders precursor skills are already not developed during infancy."

Prof. Natalie Boll-Avetisyan

Prof. Boll-Avetisyan developed the play object for studies in the BabyLAB at the University of Potsdam and has since patented it: Externally, it is nothing more than a wooden box with two green push buttons. As simple as it appears, the interior structure of the box is exciting. The electronics inside ensure that tones sound at the touch of a button. It also measures how often and how long the child presses which button when it perceives certain sounds, words, and intonations. Small, compact, portable, and with an easy-to-understand application – this makes the box well suited for mobile use.

Supporting preventive medical examinations

Boll-Avetisyan would like her toy to be used in the future during the pediatricians' U6 checkup (early diagnosis and prevention examinations), that is for infants 10-12 months old. "We wanted to have a tool that can determine a status during the regular visit to the pediatrician." Until now, the little ones are only being tested for their language development at the U7 checkup, when they are about two years old. Among other things, they have to demonstrate a certain vocabulary during this examination. It is tested which words the children understand, which ones they use and whether they can form short sentences with them. "But not all language disorders come down to a small vocabulary," Boll-Avetisyan explains.

Currently, however, the diagnosis of a speech disorder is made at the age of four at the earliest. "Risk screenings at both U6 and U7, whose results are combined, could lead to an earlier diagnosis," Boll-Avetisyan says. "A speech disorder cannot be cured but can be treated well. However, treatment methods are more effective the earlier you begin."

At the beginning of the project, which was awarded the FöWiTec Prize of UP Transfer GmbH in 2021, Prof. Boll-Avetisyan and her team tested which preference the babies have for stress patterns of artificial

THE RESEARCHER

Prof. Dr. Natalie Boll-Avetisyan studied linguistics at Johannes Gutenberg University Mainz and Utrecht University. In 2012, she received her doctorate from the Utrecht Institute of Linguistics. Since 2010, she has been working at the University of Potsdam. In 2019, she was appointed Junior Professor for Developmental Psycholinguistics and is now researching early language acquisition.

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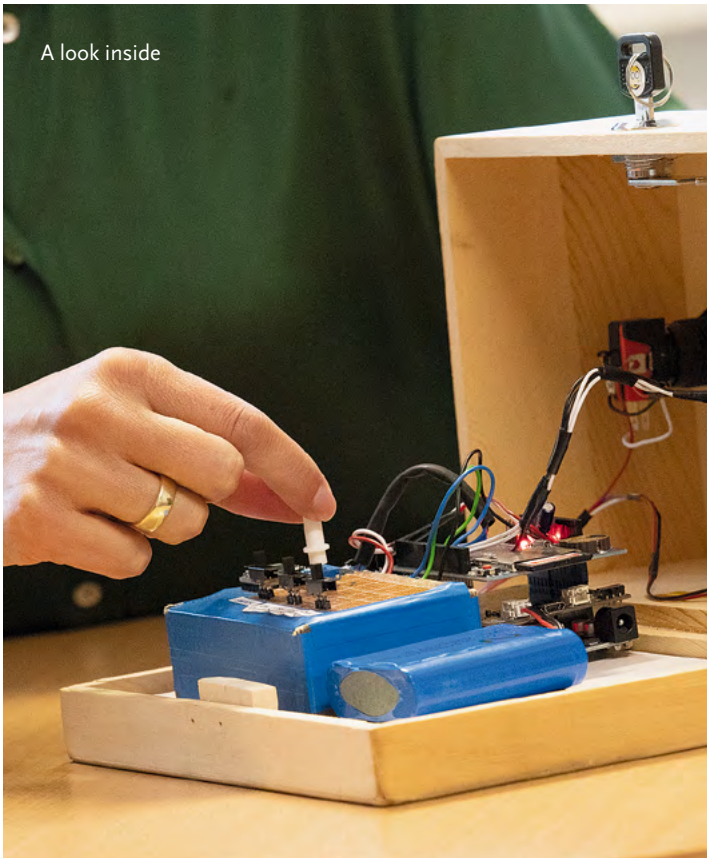
Photo: Sandra Scholz

The box is intensively tested at the BabyLAB of the University of Potsdam.



A look inside

words. The result was clear: “The children would rather hear the German stress pattern than one that does not occur frequently in their mother tongue.” This means that, even as babies, they prefer a stressed first syllable, which is typical in German.

Language preferences put to the test

With the help of the two push buttons on the toy, Boll-Avetisyan is able to record how the children react to different phonetic stimuli as pairs of opposites - and prompt these reactions, so to speak. In the future, the researcher wants to use it to investigate further reactions to other stimuli: Do the babies prefer spoken words to noise? Do they prefer real words to artificial words? Are they more likely to respond to speech directed at the child than to how adults talk to each other? Whether one can clearly assign a disorder based on these preferences can so far only be roughly determined. Too little research has been done on language development disorders.

However, it is known how the clinical picture manifests itself. “Children with developmental language disorders do not understand long sentences well or have to search for words for a long time,” she explains. “If their everyday life is characterized by misunderstandings and frustration, the affected children can develop mental illnesses that accompany them throughout their lives.” How many symptoms the children have varies a lot. Prof. Boll-Avetisyan therefore wants to raise awareness of the disorder among parents, in kindergartens and schools, and provide the respective education.

So, it is even more important to make the test toy fit for the pediatrician's practice: Boll-Avetisyan wants to prepare a guideline for the practitioners that lists criteria and standard values that facilitate risk identification. In addition, the toy will be equipped with a display so that doctors can easily evaluate the results. Before it can be launched on the market, the researcher still has to validate it for medical purposes. For this, she would like to seek support from the colleagues in Potsdam.

It was proven that the babies enjoyed playing with the box. Some engaged with it for up to a quarter of an hour. Even in the first study, it was shown that the children pressed that button for longer, which the researchers expected them to prefer. In concrete terms, this means that the toy works as they hoped. Now it is only missing a name.

LUISA AGROFYLAX

TRANSLATION: SUSANNE VOIGT

Photos: Tobias Hopfgarten (left); Sandra Scholz (right)

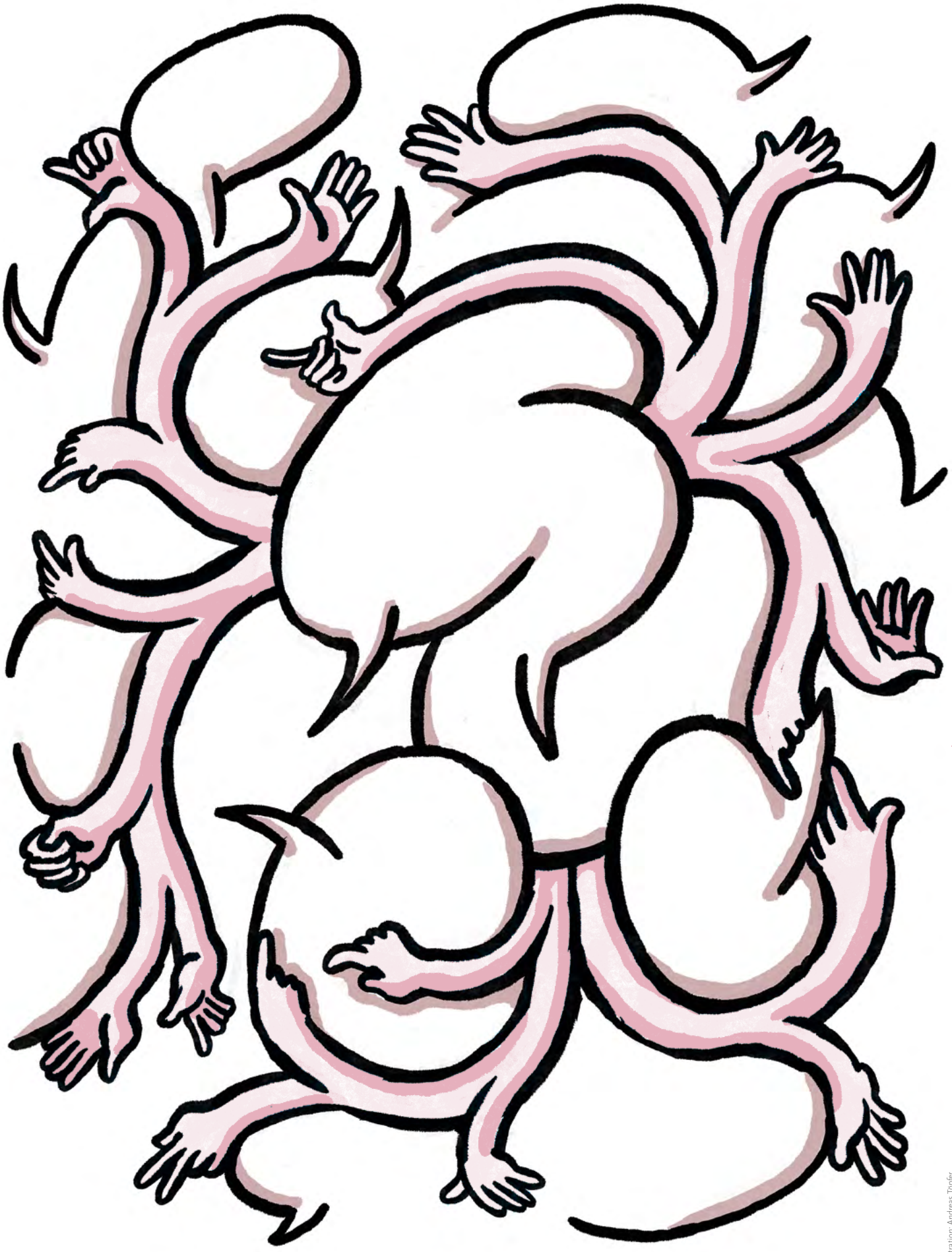


Illustration: Andreas Topfer

Face to Face

David Schlangen wants to enable artificial intelligence to interact with us in real time

Whether in an online help chat or when calling a service provider on the phone: communication with dialogue systems has become omnipresent. Most of the time, we encounter prefabricated statements that often don't fit our situation at all. Wouldn't communication work much better if the system also knew what we were looking at? If it told us which screw to drill into which board or which cable to plug into which socket of the router? And then also helped us if we had taken the wrong board or cable? The RECOLAGE project, funded by the German Research Foundation, aims to enable computer systems to react to their human counterparts within seconds. Prof. Dr. David Schlangen manages the project. For years, the computational linguist has been looking into the interaction of humans and artificial agents.

↗ The detailed article

Computational linguist
Prof. David Schlangen

THE RESEARCHER

Prof. Dr. David Schlangen studied computational linguistics, computer science, and philosophy. Since 2019, he has been Professor of the "Foundations of Computational Linguistics" at the University of Potsdam.

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David Schlangen has been Professor of the "Foundations of Computational Linguistics" at the University of Potsdam for three years. But he is not entering new territory here. At the beginning of the millennium, he already did research in Potsdam for many years as a postdoc and, starting in 2006, led the Emmy Noether Group "Incrementality and Projection in Dialogue Processing". From 2010, he was Professor of Applied Computational Linguistics in Bielefeld, where he was involved in the Cluster of Excellence "Cognitive Interaction Technology". "I came back because of the very good institute, the highly qualified colleagues, and the opportunities this position offers me," he says. "In addition, the Cognitive Systems Master's degree program is excellent and brings a steady stream of very good students to Potsdam."

When computers tell us what to do

Prof. Schlangen and his team focus on language, but the researchers also take into consideration the human body and its physical environment. "Our goal is that artificial systems are situated in time in the same way that human conversation partners would be," Schlangen says. "We want to get to the point where an interaction with agents is more like a face-to-face conversation than a chat conversation." That is why the Potsdam computational linguists like to use robots that have a body or at least a head – such as Furhat, which is available for studies in the computational linguistics lab at the University of Potsdam. In the RECOLAGE project, Furhat gives instructions to humans - in Pentomino. Schlangen has been using the game, which is reminiscent of the classic Tetris, since his postdoc days. "It lends itself to being a simplified domain that offers certain degrees of freedom but at the same time a relatively large amount of control." As the instruction is given, the robot can see from the human's reactions whether it has been understood correctly. It might someday be possible, for example, for a computer system to help us assemble a piece of furniture according to Ikea instructions, also partly thanks to another area of artificial intelligence – image processing.

"Take that board over there and the little silver screws", such a computer system might say to us. With the help of a tablet, the system would not only record what we say, but also watch us via a camera and help us to assemble the various components around us. If we reach for the wrong part, it should correct us immediately. "The linguistic correction results from the respective context, which is what makes it so complicated," says Schlangen. "Because it's about milliseconds here." If, for example, the computer system observes that the human's hand is moving in the wrong direction, it should react while the human is still doing so – in real time and not only when the screw has landed in the wrong board. That's why the computer has to anticipate where the human is going to reach. This can also go wrong if the robot predicts a movement that we didn't intend to do. "But something like that can also lead to disturbances between two people who know each other well," says Schlan-

Photo: Tobias Hopfgarten

gen and laughs. In order to interpret and implement the system's instructions easily, the common basis of understanding between machine and human must be negotiated. Which technical terms should the computer explain, which can it assume to be known? After all, if the human counterpart does not understand the instructions or does not feel properly understood, he or she will find the communication exhausting. Then the system would no longer be a real support.

Simulating human behavior with computer models

Machine learning is an essential element of Schlangen's research. The point is to generate knowledge from experience: The computer system receives learning data, from which it derives rules and which it can, ideally, apply to new situations. However, the computational linguist is to some extent critical of deep learning models – a specific method of machine learning in which artificial neural networks are supposed to facilitate deeper learning. Such models can look very convincing when it comes to a short chat conversation, for example. "But when we're dealing with an embodied computer system, a robot in human form, there's a lot that needs to be controlled simultaneously – not just speech but also facial expressions and gestures, all in a short time." After all, the robot can't maintain one facial expression for ten seconds until the next one comes because that would again already be interpreted by the human. Because deep learning models have not learned from situations in real time but from "dead" data, they are, in Schlangen's view, only suitable to a limited extent for processing information under time pressure and reacting accordingly. "In order for the behavior of the artificial agents to fit the situation, we need more computer models that have to be extremely dynamic."

That is why the researcher is working with cognitive scientists of the University of Potsdam who model cognitive processes. "We use different models from our colleagues who work very precisely on smaller phenomena, such as predicting eye movements. Our task is to put these theories together and, in this way, develop language systems that simulate human behavior." The researchers also plan to use robots for psychological or linguistic experiments, which is a rather unusual approach so far but one for which there are good arguments. "They are very well suited as a controlled counterpart. A robot can mercilessly produce stimuli that are exactly identical for every subject."

When computer systems seemingly become more and more like us, the question arises how they differ from us at all. In his research, Schlangen is often confronted with the phenomenon that precisely what is easy for us humans is difficult for computers (and vice versa - just think of demanding arithmetic tasks). Small talk, for example, is an uncomplicated everyday activity for humans, but it poses challenges for computer systems. They regularly make mistakes. "That's not so problematic. It happens to us, too. But unlike computers, we are very good at correcting ourselves." For the scientist, it is therefore clear that computer systems cannot perfectly simulate us humans. On the contrary, it should always be clear that they are artificial agents. "But they should be understandable and react appropriately to the situation, behave 'naturally'." But why is it apparently so difficult to achieve 'natural' behavior in artificial agents? "Perhaps they lack something fundamental," Schlangen suggests. "They are fed text, whereas the newborn is encouraged and challenged in interactions from the very first moment. Interaction is fundamental to us humans and is one of our innate learning mechanisms. We do not learn in passive observational situations but want to understand and communicate. In my view, it is essential for our human interaction that we understand each other and our counterparts as intentional agents." Schlangen therefore does not believe that computer systems will soon be able to communicate naturally, or perhaps even intentionally, with the help of the current methods. "On the other hand, ten years ago, I would not have thought possible what artificial intelligence can do today."

DR. JANA SCHOLZ
TRANSLATION: SUSANNE VOIGT

THE PROJECT

RECOLAGE: Real-Time Vision-Grounded Collaborative Language Generation

Funding: German Research Foundation (DFG)
Duration: 2019–2023
Principal investigator: Prof. Dr. David Schlangen

Robot Furhat

Photo: Sandra Scholz

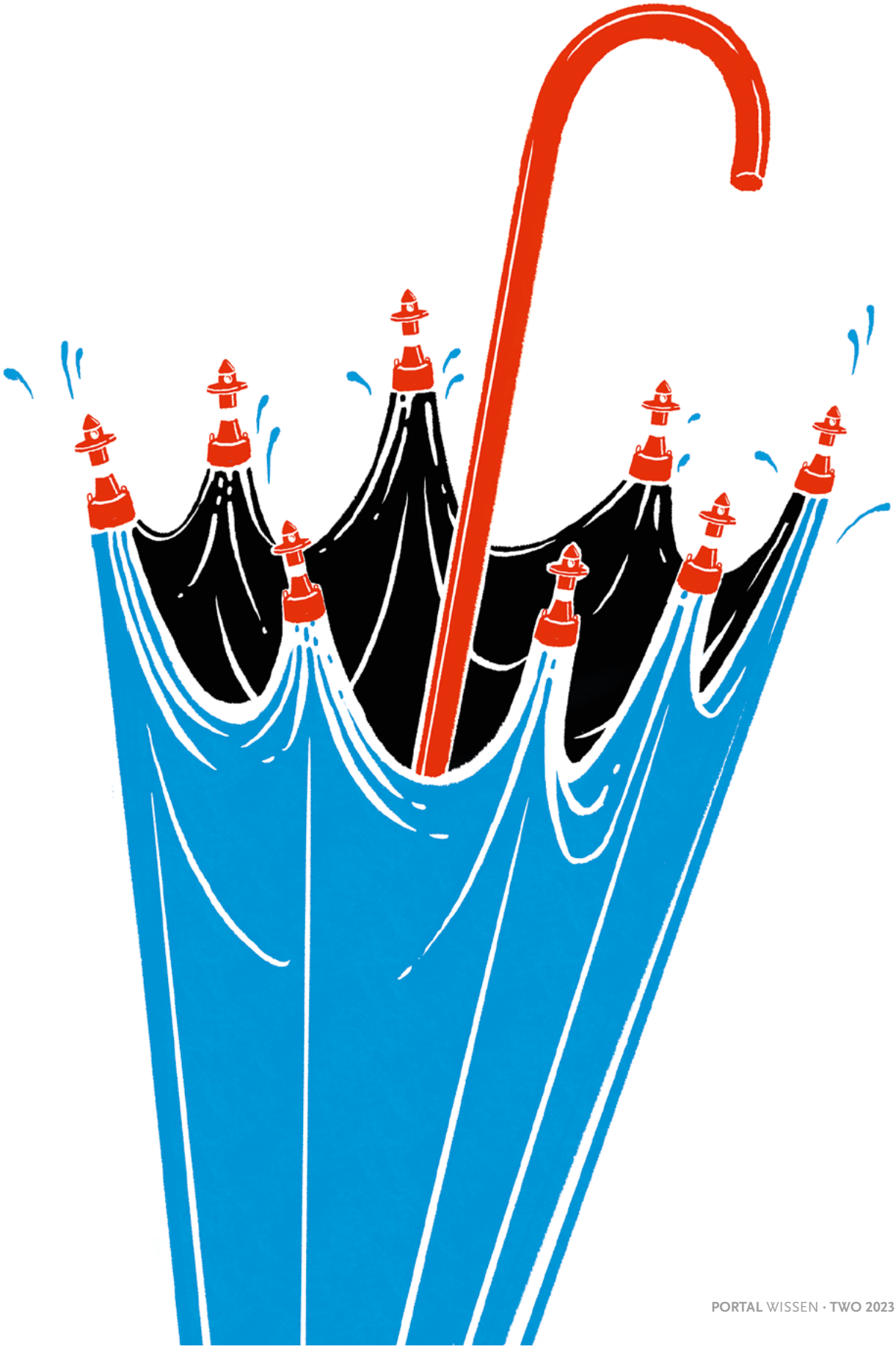

Illustration: Andreas Töpfer

Recognizing dangers during floods and droughts

Science looks at risks of extreme events

Masses of water pushing mud and piling up debris. Idyllic streams that turn into raging rivers within just a few hours, burying bridges, houses, and roads like toys. We still remember the pictures of summer 2021 from the Eifel region: The flood disaster claimed the lives of almost 190 people in Germany alone and caused property damage running into billions of euros. Only a year later, an extraordinary drought hit the whole of Europe with significant consequences for our society. Tank trucks had to supply villages in northern Italy with drinking water, shipping on the Rhine came to a virtual standstill, and in many regions agriculture suffered dramatic losses. Such extreme events push our society to its limits. That is why scientists from Potsdam are specifically researching such events: They want to quantify, classify, and manage extreme water events from all perspectives. The University of Potsdam hopes to prevail in the excellence competition with its affiliated partners with this project. Silke Engel talked to the three initiators of the proposal, Prof. Thorsten Wagener, Prof. Dr. Annegret Thieken, und Prof. Dr. Peter van der Beek, about natural risks, the role of water, and protection against disasters

Why do we find it so hard to deal with extreme weather events?

Thieken: Because – as the name suggests – they are extreme and usually occur unexpectedly at exceptionally long intervals. Societies can adapt well to risks when they are associated with frequent and repeated events. But risk governance fails in the face of infrequent events, which, on average, occur less than once in 100 years. These extremes are often missing from the series of measurements on which we base our normal planning. Thus, our picture of extreme events is incomplete, leading to a chain of consequences.

Van der Beek: The main problem is that our measurement series are too short to accurately describe and estimate the variability of what can occur, both when there is too little water and when there is an extremely large amount of water. In addition, certain data have not yet been incorporated, such as geological time series of sediments to understand historical floods. That has an impact on risk assessment. The strength of extreme events, which are now also increasingly changing due to climate change, takes us repeatedly by surprise.

Prof. Thorsten Wagener

Prof. Thorsten Wagener, Ph.D. studied civil engineering at the University of Siegen, TU Delft (Netherlands) and Imperial College London (UK). He has held professorships at Pennsylvania State University (USA) and the University of Bristol (UK). Since January 2021, he has been the Alexander von Humboldt Professor for Hydrologic Systems at the University of Potsdam.

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Wagener: The research community has yet to acquire the interdisciplinary knowledge and modeling capability to holistically quantify the complex risks of future water extremes. This includes interactions and feedback with as well as within society. This scientific gap has so far prevented us from building the much-needed framework that could provide the insights that enable effective and robust decision making for resilient societies.

Can you give an example of this? Why do extreme events confound the findings?

Thieken: Let's take dikes: These are built to protect the areas behind them and to allow certain uses, such as agriculture. Dikes limit recurring floods and protect the settlements behind them, which therefore grow because people feel safe. If a historic flooding suddenly occurs and destroys the dikes, not only the protection from the water fails, but the effects are more drastic than they would have been without the dikes. In the literature, this is called a paradox because the protection provided by the dikes was supposed to prevent the damage, but now it significantly increases the impact of the destruction. That is the pitfall with technical or structural measures such as dikes. They

Prof. Peter van der Beek

Prof. Dr. Peter van der Beek studied geology at Vrije Universiteit Amsterdam. For over 20 years, he was a researcher at the Université Joseph Fourier in Grenoble, France. Since 2020, he has been Professor of General Geology at the University of Potsdam.

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Prof. Dr. Annegret Thieken studied geo-ecology at Technische Universität Braunschweig and environmental sciences at the University of Amsterdam. Since 2011, she has been Professor of Geography and Disaster Risk Research at the University of Potsdam.

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stand their test within a certain framework for which they are designed. If that is exceeded, you would need a second plan. In the Netherlands, for example, there is a "polder concept" so that if a dike breaks, the water cannot spread unhindered but remains within a certain ring.

Wagener: Reservoirs or dams, which we build to bridge dry periods, can lead to paradoxical behavior too. Reservoirs tend to increase water use. If droughts occur more often due to climate change, the water capacities will be far from sufficient to supply the ad-

Photos: Kevin Ryl (top left, top right); Tobias Hopfgarten (bottom)

jacent areas with water. The consequences of droughts will be more calamitous for people than they would have been before the reservoir was build. This cannot be prevented entirely, but the risks can be minimized when findings of such side effects are included.

Where does the University of Potsdam already have profound knowledge that can be developed?

Thieken: In Potsdam, we look back on a more than 150-year-old research tradition in the geosciences. This has given rise, for example, to the German Research Centre for Geosciences (GFZ) and the Potsdam Institute for Climate Impact Research (PIK). In the midst of all this is the University of Potsdam. Although with its 30 years it is much younger, it has always focused on natural hazards and interdisciplinary networking in the geosciences and environmental sciences. Just think of the "Geo.X" platform for geoscientific research in Berlin and Potsdam.

To emphasize this prioritization, professorships were created at the University of Potsdam ten years ago to study both natural hazard processes such as landslides or floods and to look at societal risks. In other words, we have been investigating for a long time the societal impacts caused by natural hazards. How can these risks be minimized? And that, of course, is a good bridging function, on the one hand to other natural science chairs of hydrology, geology, and mathematics and on the other hand to the administrative and political sciences, which analyze the consequences of climate change for decision-makers in society. With the application for an excellence cluster, we are creating an excellent foundation to advance this interdisciplinary expertise.

Wagener: The University of Potsdam is at the center of a thriving, inspiring, and growing research environment with a particular focus on risks from natural hazards and water extremes. Leading researchers are already working together here to understand the system Earth. Through joint professorships with said institutes – PIK, GFZ, and also the Center for Environmental Research (UFZ) in Leipzig and the Institute for Agricultural Engineering and Bioeconomy in Bornim (ATB) – the University of Potsdam has established a research community on which we are building now. Our cluster integrates internationally leading researchers such as the jointly appointed professors Johan Rockström (PIK) and Bruno Merz (GFZ) and exceptional researchers who are still at the beginning of their careers, such as Prof. Eva Eibl (University of Potsdam) and Prof. Jakob Zscheischler (UFZ). We also bring together researchers from all disciplines to which water extremes are relevant. It is very important that we link this natural science research much more strongly with the social sciences and involve experts from the University of Potsdam such as Prof. Sabine Kunstmann and Prof. Julia Fleischer.

Van der Beek: Remote sensing is one of the big strengths in Potsdam, for example with Prof. Dr. Bodo Bookhagen at the University of Potsdam and Prof. Herold at the GFZ as a professor affiliated with the university. I think what makes Potsdam special is the very strong connection between the university and the non-university institutions. There are many joint appointments, and collaborations are well coordinated, as can be seen not least in the many interdisciplinary doctoral projects. A unique practice, well established and with potential that is far from exhausted. Nowhere else is there such a strong regional concentration of competence and methodological diversity. In addition, there are joint master's and doctoral programs and a wide range of research projects that already link the university with its non-university partners. Developing these existing synergies into an excellence cluster will enable us to use the current momentum to create an environment for world-leading research, education, and knowledge exchange.

How can the strengths of the Potsdam research area be pooled?

Wagener: The University of Potsdam and our participating partners are already scientific leaders in the primary areas of the proposal: For example, our researchers advance large-scale monitoring of the Earth system by conducting and developing innovative ground- and satellite-based measurements. We introduced seismic monitoring to track the evolution of mass erosion and flood events. We were the first to install a cosmic ray neutron measurement system on Deutsche Bahn trains to quantify soil moisture dynamics on an unprecedented scale. Our progress in observations is not limited to physical processes. We have also collected and analyzed extensive social science datasets to decipher the dynamics and heterogeneity of human vulnerability and behavior in response to water extremes.

Van der Beek: The researchers of the University of Potsdam, PIK, GFZ, UFZ, and ATB, who are involved in our proposal, have gained extensive new insights into hazard processes caused by water extremes and how they are influenced by climate change. For example, we have been able to show that extreme floods are influenced by processes that significantly differ from those driving more frequent floods. This has crucial implications for their prediction and management. We examine how climate change affects the frequency of floods, landslides, droughts, and forest

The Loire, shrunk to a small river in the French Département of Charente-Maritime

fires. And most importantly, we study the interconnections of these extremes, as they often have much greater impacts when combined than when they occur alone.

Will science be able to prevent catastrophes, such in the Ahr Valley, in the future?

Thieken: It cannot completely prevent them, but it can better assess risks and damages and initiate measures in good time to reduce damage. Experts in the Ahr Valley, for example, are already systematically looking for retention areas in which any water masses that occur can be temporarily stored. This is definitely important to cut the peak so that not all of the precipitation from heavy rain gets directly into the river. Building dikes is out of the question in a narrow valley. During the flood in the Eifel, we also saw that cars, tree trunks, debris, and sediment washed along and clogged the bridges. At some point, the water pressure was so strong that a wave broke through, which then in turn raged even more severely and tore down the bridges. This means that good concepts are needed for such neuralgic points during reconstruction. Bridges should be more open and larger to prevent these blockages. Extreme events are marked on maps to designate high-risk areas. These regions need to be evacuated earlier to at least minimize the number of casualties, and also to keep people's exposure to flood waters low. Many experienced the flood firsthand during the night – a traumatic event that comes with a sense of being out of control. This calls for good warning systems, functioning disaster control, and ideas to make reconstruction relatively quick and uncomplicated.

Wagener: Potsdam already has a wide range of expertise in this area, too. We have developed empirically derived flood damage models, which consider influencing factors such as physical processes but also human behavior. This makes assessments more precise and predictions of flood consequences more realistic. We are among the first to study and quantify interactions in international multi-level risk governance, demonstrating, for example, the important influence of informal actors in shaping climate policy. We compiled the first global dataset to show that we are learning insufficiently from repeated droughts and floods. While this is a negative result for now, it also shows that we can do much better in the future if we improve the scientific basis of our decisions.

Van der Beek: This is precisely where we increasingly need the social sciences. Society is not a passive recipient of risks. Our behavior actually increases risk to

some extent, for example by living in hazard zones. We need to better understand the dynamics between extremes and society. In addition, communication and transfer of science-based facts are becoming more relevant for decision-makers and opinion formation in society. In the future, policymakers will have to provide information about hazards with large uncertainties. We cannot prevent extreme precipitation events, but we can prevent them from impacting our lives.

Your vision: to understand and simulate water extremes and to respond to them with guidelines for action. A very large undertaking that aims for the stars?

Van der Beek: We are well positioned to start here with larger visions and projects. Cluster research allows us to work in larger groups to make even more progress in the long term than anything we have done so far. To protect ourselves from extreme events, we urgently need to advance our models and develop our research methods. Of course, it is also important to slow down climate change itself. But at the same time, we need to better understand these extremes so that we can prepare ourselves against them.

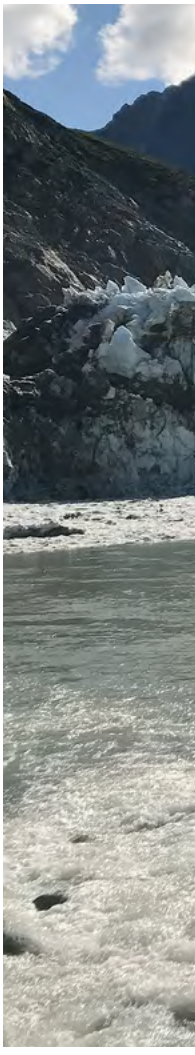
Thieken: And the susceptibility to damage is becoming a central issue. Here we want to collect data in a very targeted way. So-called "longitudinal studies" are important, in which individuals are accompanied over a longer period of time in order to collect longitudinal data on their precautionary behavior, perception of hazards, protective options, resources, etc. Based on the results, we can then develop significantly better models, so that the predictions are significantly optimized.

Neckargmünd under floodwaters

Ahrweiler, one year after catastrophic extreme weather events
▸ p. 52

Photos: Dr. Philipp Bubeck (bottom); AdobeStock/Dwi (top)

CRNS probe – for measuring soil moisture – in a field test



What is new and how do you extend existing approaches?

Thieken: We bring together three major fields of research: natural hazards/processes, their interaction with society, and integrated models for visualization. In this way, scientifically based findings are processed in a nuanced and comprehensible way. On such a basis, political decision-makers can take into account different scenarios. We plan to use virtual reality tools to support such decision-making processes by making the scenarios comprehensible. We ventured the attempt to translate basic research into application and transfer. There can be no greater added value, don't you think? Take the Harding Center, for example, which is famous for its risk communication. Risks are based on probabilities, but many decision-makers struggle to interpret appropriate models or studies correctly. We want to use the valuable work of the Harding Center to better communicate our results so that people are able to understand and interpret these probabilities, too.

What will be the benefits of an excellence cluster for the University of Potsdam?

Wagener: A cluster in this area would be a great achievement. For Potsdam, Brandenburg, and beyond. There is a huge need for a better scientific basis for decision-making by cities, municipalities, states, the federal government, and also international organizations like the World Bank. It would be the logical continuation of the work we are doing in Potsdam. In terms of content and collaboration, I expect a real push that will intensify and expand the interdisciplinary cooperation of mathematics, physics, geosciences, environmental sciences, but also political and administrative sciences. We expect that an excellence cluster on water extremes will lead to ground-breaking progress in the next decade. We aim for an integrated description of risk based on a gradual change of our quantitative understanding of rare water extremes and their interaction with society (human behavior and management). An integrated science-based approach would enable considerable progress along the entire

Photo: Universität Potsdam/ZIM

Outbursts from ice-dammed glacial lakes, such as Lake No Lake in British Columbia, are changing in the course of climate change.

risk chain in the integrated human-earth system: from understanding to prediction to management.

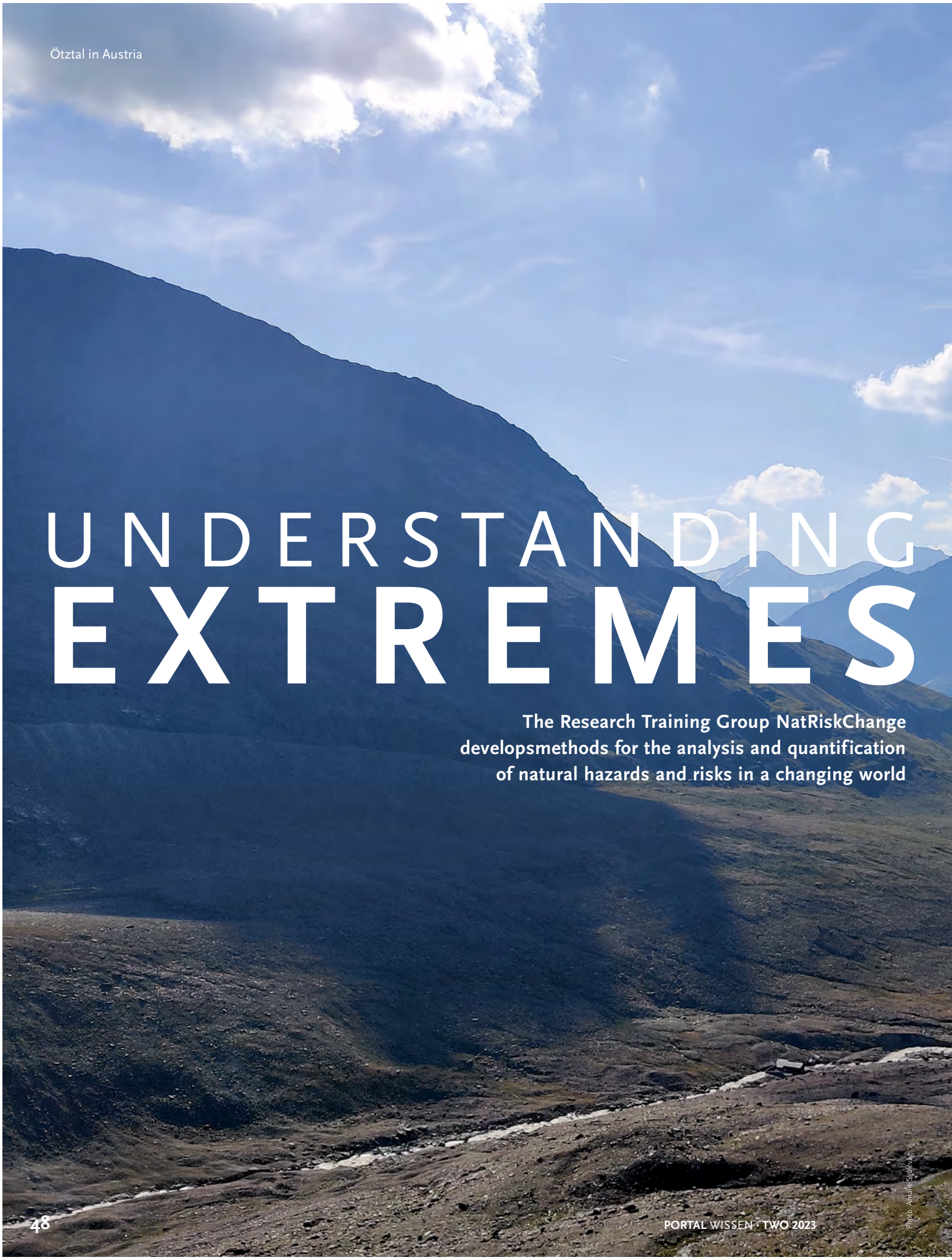
The cluster could help train a new generation of researchers?

Van der Beek: It cannot be stressed enough what impact a cluster would have on the academic community in Potsdam. It would decisively promote the development of the University of Potsdam into the research university we want it to be. Such a cluster would create a unique, internationally leading center of excellence for water extremes and their risks. The cluster would enable the training of a new generation of researchers and the development of a joint scientific culture across academic disciplines, which is essential for understanding and addressing the complexity of water extremes.

THE INTERVIEW WAS CONDUCTED BY DR. SILKE ENGEL. TRANSLATION: SUSANNE VOIGT

The researchers of the "NatRiskChange" Research Training Group are also on the road in the Ötztal valley.
▸ p. 48

Photos: Dr. Georg Veh (top); Annalie Skåleväg (right)



Ötztal in Austria

UNDERSTANDING EXTREMES

The Research Training Group NatRiskChange developsmethods for the analysis and quantification of natural hazards and risks in a changing world

Photo: Annalie Skalet Ag

Changing conditions, such as global warming and land use, can strongly influence the occurrence of natural hazards and the risk they pose. "It is the goal of NatRiskChange (Natural Hazards and Risks in a Changing World) to develop methods that improve the analysis of the frequency, magnitude, and impact of natural hazards," says Prof. Annegret Thieken, speaker of the Research Training Group.

"A natural hazard is a physical process that negatively impacts society," says Lisa Luna, a PhD student in the second cohort of NatRiskChange, which started in 2018. Some of the PhD students are looking at the risks posed by landslides. Others are investigating the risks of floods, droughts, heavy rainfall, or earthquakes. In addition to assessing hazard, they also research the risks, that is, the possible effects and damage caused by natural events. The primary question here is vulnerability: How resilient is society to a particular hazard? "For example, how might a flood in a certain area affect the people and infrastructure there?" Luna summarizes. Her own project focuses on how to better predict landslides. "So far, I've looked at the seasonality of landslides, i.e. during which times of the year they are more or less likely to occur, and how many can be expected."

The water engineer Joaquin Vicente Ferrer, on the other hand, is interested in the anthropogenic triggers of landslides, i.e. whether changes in land use by humans result in more landslides. "It is quite conceivable that companies build a dam downstream without knowing that this can trigger a large landslide elsewhere along the river." In recent years, he already dealt with various natural disasters such as floods, typhoons, and tsunamis. "In my doctoral thesis, I am now looking at the largest landslides worldwide. These have always interested me," he says. "They have a low probability but can have devastating impacts."

Like Ferrer, Amelie Skålevåg started her doctoral studies in 2021 with the third cohort of "NatRiskChange". She is researching changes in freeze-thaw regimes in alpine regions and the effects of global warming on glacier retreat and erosion processes. "I want to know how temperature change in high mountain regions affects sediment production and influences the dynamics of the system," she says.

To this end, she has conducted fieldwork in the Tyrolean Ötztal. With the help of statistical methods, she wants to determine and analyze trends in these processes.

Very close with the help of task forces

To ensure that the PhD students in the Research Training Group work together in an interdisciplinary way and also contribute to the understanding of current damaging events, application-related task forces have been set up as an integrative part of the qualification program. "In a task force, PhD students and supervisors come together to work on a recent natural hazard that has come to their attention," Luna

THE RESEARCHERS

Prof. Dr. Annegret Thieken studied geoecology at Technische Universität Braunschweig and environmental sciences at the University of Amsterdam. Since 2011, she has been the head of the working group Geography and Disaster Risk Research at the University of Potsdam. She is the Speaker of "NatRiskChange".

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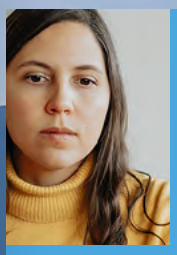

Lisa Luna studied geology at Middlebury College (USA) and geosciences at the University of Potsdam. Since 2019, she has been doing her doctorate in the Research Training Group "NatRiskChange" on improving predictions of landslides.

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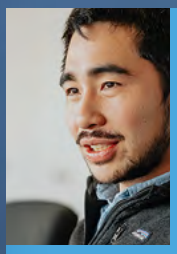

Joaquin Vicente Ferrer studied water science and water technology at IHE Delft Institute for Water Education and civil engineering at the University of the Philippines Diliman. Since 2021, he has been doing his doctorate in the Research Training Group "NatRiskChange" on predictions of large landslides in a changing world.

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Amalie Skålevåg studied geoecology at the University of Potsdam and environmental modelling at University College London. Since 2021, she has been doing her doctorate in the Research Training Group "NatRiskChange" on changing water and energy conditions and their relevance for water and sediment transports in the Alpine areas.

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Photos: Tobias Hergarten (top), Kevin Rivi (3)

THE PROJECT

The Research Training Group **"NatRiskChange"** researches natural hazards and risks in the face of changing conditions in the environment and society.

Participants: Potsdam Institute for Climate Impact Research (PIK),
Helmholtz Centre Potsdam – German Research Centre for Geosciences GFZ,
Freie Universität Berlin and Helmholtz Centre for Environmental Research (UFZ)
Funding: German Research Foundation (DFG)
Duration: 2015–2024

www.uni-potsdam.de/en/natriskchange

summarizes. "This was one of the highlights of my PhD years." Skålevåg adds, "Whoever is interested and has time can contribute. In the end, there has to be a product such as a report, a publication, or a website." PhD students are required to participate in at least one task force during their time with the research training group. In recent years, task forces were set up following the Eifel floods in Germany in summer 2021 and the 2019/20 wildfires in Australia, among other events. In a current task force, Ferrer is investigating flash floods in Italy in summer 2022. "Coming together to see what others are doing and what methods they are using gives me new insights for my own project," he explains.

Another applied research opportunity arose for Luna when she was able to contribute to an early warning system for landslides. In a joint project with the University of Oregon, her knowledge of statistical modelling was implemented in a real-time online dashboard that estimates landslide hazard based on observed rainfall data and weather forecasts in the city of Sitka, in southeast Alaska, USA. "I really liked the applied aspect," she says. "I thought if we did our job well, we could really get better information about landslide risk in Sitka."

Photos: Kevin Ryl (2)

Strong team spirit

The PhD students agree that the most important aspect of working in the Research Training Group is the supportive network of young researchers. “The collaborative concept of NatRiskChange was a big motivation for me to do a doctorate in the first place,” says Skålevåg. “We are lucky to always be able to exchange ideas with the PhD students from the first two cohorts,” adds Ferrer. “This overlap made me feel less lost in my first year.” Networking among the PhD students is also promoted by two- to three-day closed-session meetings held twice a year, where all projects are discussed with the supervisors. “This not only promotes team spirit but also an interdisciplinary understanding and better management of natural hazards,” Prof. Thieken is convinced. The network, which was built over the past few years, is also a great asset for the future of natural hazard research worldwide. Some alumni carry the ideas and concepts of the Research Training Group into international companies or other research institutions. Among other things, the University of Potsdam’s collaboration with the Indian Institute of Technology Roorkee was intensified in this way and is to be continued in future joint projects.

STEFANIE MIKULLA
TRANSLATION: SUSANNE VOIGT

Her fieldwork took PhD student Amalie Skålevåg to the Ötztal valley.

Photos: Amalie Skålevåg (2)

Photo: Dr. Philip Bubeck

Bad Neuenahr-Ahrweiler is still scarred by destruction more than a year after devastating extreme weather events.

AFTER THE FLOOD

In the project KAHR, researchers, together with authorities, municipalities and those affected, investigate what can be learned from reconstruction in the flooded areas along the Ahr and Erft rivers.

In July 2021, parts of Rhineland-Palatinate and North Rhine-Westphalia experienced one of Germany's most severe natural disasters after 1945. The floods on the Erft, Ahr, Inde, Vicht, and Wupper rivers claimed the lives of more than 180 people and caused damage of over 30 billion euros. Environmental scientist Phillip Bubeck recently visited the flood zone on the Ahr River. "In the center of Bad Neuenahr-Ahrweiler, the damage is still clearly visible," he says. "You can see the remains of the destroyed bridges and the temporary makeshift bridges. Only a few stores are open. Many buildings have been marked by the water and are nailed up with plywood. We are far from normal." But the researcher also saw that reconstruction was progressing in many places. "Many streets have been repaired and redone, and one pizzeria had put up a sign on which the mayor congratulated it on its reopening."

Philip Bubeck is environmental scientist at the University of Potsdam and member of an interdisciplinary research consortium initiated by the German Federal Ministry of Education and Research a few months after the flood. In the KAHR research project – Climate Adaptation, Flooding, Resilience – 13 institutions support reconstruction in the disaster area. Their expertise in water management, spatial and urban planning, and social sciences is being used to review and reappraise the events. It is expected to lead to new concepts for better risk management and protection in flood risk areas.

Hotel Steigenberger in Bad Neuenahr

Psychosocial consequences still inadequately researched

"We know very little about how reconstruction works or about the psychosocial consequences of such a disaster," Bubeck explains. He and his colleagues are using questionnaires to try to find out more about what is going on in the minds of the affected people

Photos: Dr. Philip Bubeck (2)

and how they cope with what they have experienced. What damage did private households and businesses sustain? How high was the water? Was it polluted? How did people try to protect themselves, and will they take precautions for the future? "Such severe events put an enormous psychological strain on people, which can last for years," he knows. Mental health is therefore one of the team's research priorities – especially since the data on this to date is sparse. The researchers want to create hotspot maps based on the survey results that show where there is the greatest need for support.

Prof. Dr. Christian Kuhlicke, urban and environmental sociologist at the Helmholtz Centre for Environmental Research (UFZ) in Leipzig and Professor for Sustainability and Environmental Risks at the University of Potsdam, also concentrates on the local actors. "From the level of neighborhoods to the municipalities to the state, from the mayor to companies to spatial planning and water management: More than 200 actors are involved in reconstruction," he explains. He is interested in how reconstruction is being shaped and what factors are significantly influencing the nature of reconstruction. Who makes which decisions, which interests prevail, and what factors influence this? In the pilot communities of Stollberg, Eschweiler, and Bad Neuenahr-Ahrweiler, he is primarily looking at social facilities such as schools, libraries, swimming pools, or inns. "We support reconstruction, but also try to observe the process as comprehensively as possible," Kuhlicke says.

The Ahr tore away many crossings, many of which have still not been restored.

The process of repair and starting over again can reveal a lot about which levers have an effect. Political and legal frameworks, financial support, but also cultural patterns shape the process and can regulate it. "There was a one-time 'whoosh' and now we will have peace for the next few decades." That's how Kuhlicke describes the mood of many locals. People then often rebuild exactly as it was before - with all the known risks. Also because time is tight, and things have to be done quickly. Temporary shelters, which provide those affected with everything they need, could ease the pressure somewhat and create more space for the necessary search for new solutions.

THE PROJECT

"KAHR" (German abbreviation for Klimaanpassung, Hochwasser, Resilienz – climate adaptation, floods, resilience) is a research consortium initiated by the Federal Ministry of Education and Research after the flood disaster in July 2021. The 13 participating institutions support the reconstruction efforts in the region and contribute scientific expertise to improving flood risk management and increasing flood resilience.

Duration: 2021–2024
Participating: Koblenz University of Applied Sciences, German Institute of Urban Affairs, Technical University of Kaiserslautern, Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, Flood Competence Center, Institute of Spatial and Regional Planning, University of Stuttgart, TU Dortmund University, University of Potsdam, Institute of Hydraulic Engineering and Water Resources Management (RWTH) Aachen, District of Ahrweiler, Helmholtz Centre for Environmental Research, Eifel-Rur Water Association

https://hochwasser-kahr.de/index.php/de/

THE RESEARCHERS

Dr. Philip Bubeck studied politics at the University of Freiburg and environmental and resource management at the Vrije Universiteit Amsterdam. As a postdoc in the working group Geography and Disaster Risk Management, he researches the social effects of flood events, climate adaptation, and precautionary measures.

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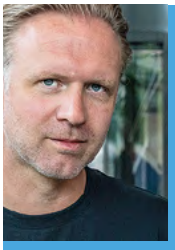

Prof. Dr. Christian Kuhlicke studied human geography, sociology, and geology in Potsdam. He is head of the Department Urban and Environmental Sociology at the Helmholz Center for Environmental Research (UFZ) in Leipzig and Professor for Sustainability and Environmental Risks at the University of Potsdam.

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Prof. Dr. Bruno Merz studied civil engineering at the University of Karlsruhe. He is head of the section Hydrology at the Helmholtz Center Potsdam German Research Center for Geosciences (GFZ) and is Professor for Engineering Hydrology and Management of Georisks at the University of Potsdam.

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The researchers want to learn from their observations and analyses how things can be done differently to strengthen the resilience and sustainability of communities. They will pass on their findings to state and federal political stakeholders and municipalities, ultimately to derive recommendations on how to better respond locally and in the future, and how to prepare for future disasters because the threat of flooding is here to stay.

Rethinking flood protection

Does such an extreme scenario impend every 1000, every 100 or every ten years? That's what Professor Bruno Merz, a hydrologist at the German Geosciences

Center (GFZ) and Professor of Engineering Hydrology and Management of Geohazards at the University of Potsdam, is trying to find out. "It was a very unusual event," he says about the recent flood. There were very heavy rainfalls in a short period of time, at the same time saturated soil that could hardly absorb water and an unfavorable topography: Water was able to run quickly off the steep slopes, collect in the narrow valleys, build up an enormous flood wave and run off with destructive power. "95% of all flood events proceed differently, but it's precisely these rare, special events that we need to understand better," Merz emphasizes. That's why we need to rethink flood protection and take such scenarios into account.

Bruno Merz provides the necessary data for this – with the help of a weather generator and a model chain. "Our weather generator is a model that generates weather artificially," Merz explains. Based on past and present weather data, the researchers simulate the weather for 10,000 years in the three heavily affected river basins of the Ahr, Erft, and Rur with a resolution of one hour. The researchers feed the data into a chain of additional models that depict water discharge in the impacted areas, flood areas, and the resulting damage.

"We generate huge amounts of data with this model chain, from which we extract rare, extreme flood events. This allows us to better assess what could happen in the region in terms of flooding and possible damages," Merz says, explaining the goal of the calculations. In the next step, the research team will extend the model to other areas and include climate change. "Many studies show that heavy rainfall events have already increased, and climate models predict the same for the future," Merz says. In the coming decades and centuries, flooding could become a more frequent and severe event in many areas.

Photos: Dr. Philip Bubeck (top); UFZ (M.); GFZ (bottom)

Reconstruction continues under the motto #wiederbunt ("vibrant once again").

Understanding extreme events and their consequences better

All this raises some new questions for flood protection authorities that are not easy to answer. Together with the German Weather Service, state ministries, water associations, and the environmental agency of the federal state, Merz's team is part of a working group in North Rhine-Westphalia. They are evaluating the currently valid flood statistics to determine whether they are outdated and need to be adjusted with new data. For all river basins in Germany, there are calculations about the kinds of floods that can be expected every 100 years. Strict regulations apply to the flood zones determined from these calculations. For example, they may not be redeveloped. Do the assessment values now have to be increased? And if so, how much? "This is not an easy discussion," Merz emphasizes. This has a major impact on flood hazard maps and flood protection measures such as dams or dikes, but also on the development plans for the affected areas. The results from the modeling should provide more clarity.

With fast computer models and big data sets, more will be possible in flood forecasting than has been until now, Merz is convinced. Currently, forecasts and warnings provide water levels at specific river gauges. But mathematical models can also provide area-wide information on potential flooding and calculate what water levels and depths, flow velocities, and damage to buildings or bridges can be expected for areas far from the forecast gauges. They can "take the established warning system to the next level," Merz explains.

At the end of the KAHR project, which is funded until 2024, the three researchers hope to have a more accurate picture not only of the material damage and social impact the flood caused in Rhineland-Palatinate and North Rhine-Westphalia, but also how to bring together the necessary actors to deal with the crisis, how to better communicate the risk, to get the warnings to people in time, and to better manage reconstruction. Different expectations and interests often collide in this process. "People are often preoccupied with very practical problems," Bubeck says. "Where can I get a craftsman and building materials?" At the same time, the authorities have to manage the crisis as a whole and to set the course. "Of course, the water industry looks at it very differently than an affected private individual or the operator of a social institution," Kuhlicke explains. Flood protection should be improved to protect buildings, but at the same time it has its limits. The population and the business sector must be informed about this. "We can create some transparency on the ground about how the various players are looking at reconstruction and support communication among them," Kuhlicke says.

Above all, the major goal of research in the disaster area is to gain scientific knowledge about reconstruction in order to be better prepared for similar events in the long term. In the future, the researchers also want to investigate this in their own Cluster of Excellence "Water Extremes", for which they will apply in 2023. "This extensive research is necessary to understand the connections and overall complexity of extreme events and their consequences," Merz emphasizes. "We won't be able to prevent something like this in the future," Bubeck says. "But we can learn how to better respond to it so that we end up with less damage and less human suffering."

HEIKE KAMPE
TRANSLATION: SUSANNE VOIGT

Photos: Dr. Philip Bubeck (2)

For the column SKETCHED, we asked the illustrator and graphic designer Andreas Töpfer to draw "natural hazards" emanating from water. He also created the illustrations on pages 1, 8, 24, 36 and 40.

Illustration: Andreas Töpfer

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