



Cover: N. Becker, DAI
The Tall Hujayrät al-Ghuzlän excavation site: A large antique storage vessel is recovered almost undamaged. Archaeologists are investigating traces of human settlements in Jordan.

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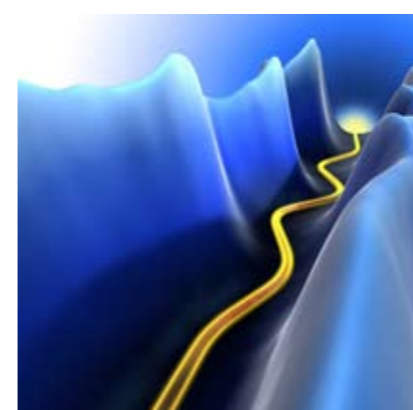


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Matthias Kleiner

A Confident Look Beyond

The finale of the Excellence Initiative has just begun – yet the scientific community must already contemplate the future of top-level research funding. We need productive and constructive dialogue with policymakers. The key issues are obvious.

At first glance, and certainly from the perspective of scientific logic, it must seem odd: across Germany, hundreds of scientists and academics, university administrations, and state ministries of research have just 2011 gone to great efforts to complete, countersign, and submit the proposals for the finale of the second phase of the Excellence Initiative. And yet, just weeks prior to scientific review of these proposals, we can open almost any newspaper and find new suggestions for the time after the Excellence Initiative.

For researchers, especially the younger ones, this must be demotivating. What's more, these early suggestions may lead the scientific community to doubt the existence of a broad consensus, shared by researchers and politicians alike, that we have undertaken this joint effort primarily for the sake of science and its progress. With the Excellence Initiative, we have entered new territory together. It was an "experiment" in the research system, one that we all agreed on because it made sense and still does. But since when is it scientific to evaluate an experiment before it's finished and draw conclusions from the results?

The logic of science would therefore say that it is too early to have this public debate – and the timing is not very helpful for those who are highly involved in this second phase of the Excellence Initiative.

Then again, it would be politically naive not to recognise that all forms of science, and the structures designed to promote them, are also tied to a political framework. And identifying the right path requires a

broad-based discussion and, as experience has shown, a long lead time. Knowing the logic of politics, one would have to say that thinking about the future can't start early enough.

One could even go further and say that it is our very responsibility towards the second phase of the Excellence Initiative and our consideration of the participating researchers and their institutions that compels us to begin early to think about the future after this second phase of the competition. And we have to invite those who are in the middle of it to put this thinking in its proper context and understand it accordingly. Even then, though, the question remains where and how we want to discuss these issues. I see no reason why we should proceed differently here than in the early stages of planning the Excellence Initiative – and that is by initiating the discussion within the scientific community and entering into a confident, productive and constructive dialogue with policymakers.

Our thinking doesn't have to start from scratch. With all the diversity of ideas, there is one thing everyone agrees on: the federal government needs to increase its commitment to science and research funding. The only question is how, and what are the most efficient ways to go about it.

There are other key issues on which everyone should agree, or come to an agreement on quickly. First, I believe that as a matter of reason and fairness, there can be no doubt that the new initiatives, to be approved for the first time in June 2012 in the



second phase of the Excellence Initiative, should be eligible for a second grant after the first five years of funding. For we have seen in the first phase of the Excellence Initiative that, despite all the preparation in the run-up to the proposal, it takes some time before the initiated processes and structures can take full effect, and results of high quality and quantity can be achieved.

Then, the universities urgently need better core support and greater flexibility. Teaching and research should not have to compete for resources – excellent teaching and research without third-party funding must be ensured, as must preparatory work for externally funded projects and financing of indirect project costs. The programme allowance for indirect project costs under the Higher Education Pact has proven essential and indispensable to providing financial relief to universities. It dovetails with the needs of science and research, is uncomplicated yet quality-assured. Increasing it to the level of international standards is an absolute necessity.

Furthermore, greater freedom of action for universities corresponds directly with the DFG's ability to respond to the growing needs of universities. The planning security provided by the Pact for Research and Innovation has enabled the DFG to do just that, and to accentuate certain areas of funding in close consultation with the major research organisations. This has proven to be very productive for the increasing interconnection and cooperation between universities and research organisations. Therefore, the long-term significance of the Pact for Research and Innovation for the entire research system cannot be overstated.

And finally, there is also agreement that the German research system needs the funding provided under the Excellence Initiative to continue after the programme expires in order to stay competitive, and that shifting these federal and state funds to other areas of political activity would undo much of what has been accomplished. To allow the work that has begun to continue, to meet the need for large-scale grants also in the long term, and to safeguard quality criteria and research-driven selection processes, the two funding lines "Clusters of Excellence" and "Graduate Schools" should therefore be included permanently in the DFG's funding portfolio. This would require the DFG to realign its coordinated funding programmes to offer flexible grant opportunities for research projects of all sizes.

Starting with these key issues, we should think beyond the Excellence Initiative. In the DFG, we have already begun this thought process and intend to deepen it over the coming months and years – in our committees, in consultation with the universities and the German Rectors' Conference, within the Alliance of German Science Organisations, and in intense conversations with policymakers. In this we are guided by our firm belief in scientific self-governance and motivated by the necessity to speak up with a strong voice for the concerns and needs of the research community.

A handwritten signature in blue ink that reads "Matthias Kleiner".

Prof. Dr.-Ing. Matthias Kleiner
is President of the DFG.

F. Klimscha, U. Siegel, R. Eichmann and K. Schmidt

Empire of the Ibex

Far from the well-known excavation sites in Egypt and Mesopotamia, an international team of archaeologists are excavating the remains of a Chalcolithic settlement in Jordan at Tall Hujayrāt al-Ghuzlān near modern Aqaba. Their finds are full of surprises – they demonstrate how social and technological innovations radiated out from the centres to the periphery.



In the history of humanity there have always been regions where particularly important and decisive discoveries have been made. These innovations permeated throughout the cultural core areas into distant regions. During the Neolithic (the younger Stone Age characterised by agricultural subsistence), for example, knowledge of the wheel and the wagon spread from the Near- and Middle-East as far as the Baltic Sea area – in a very rapid process, in hindsight taking only about a hundred years.

Technical innovations generally occur in economic-administrative centres. Cultural achievements, for instance writing, were first conceived and instigated in the Mesopotamian city states. However, archaeological research must also expect spectacular discoveries in regions considered peripheral in terms of the centres of ancient Near-eastern cultures. That is, regions where vital resources were scarce and where the environmental conditions made

life more difficult for the population rather than easier.

Tall Hujayrāt al-Ghuzlān lies in such a region. It is situated north of the modern town of Aqaba, close to the Red Sea. Today, the area offers ideal conditions for sport diving and holidays at the beach. In prehistory, though, in a society based on farming and animal husbandry, the fight for survival was hard and unrelenting. Rain falls highly irregularly and often not at all – sometimes for years at a time.

In terms of traffic infrastructure the region around the Gulf of Aqaba can only be reached with great difficulty by land: narrow, dried out river beds, enclosed on both sides by high cliffs (“wadis”) are the only roads. The Wadi Araba stretches away to the north, where nowadays an asphalt road leads to the Dead Sea. In the east Wadi Yitim leads to a stunning, but hostile desert landscape. These conditions only improve when travelling across water.

The population of Tall Hujayrāt al-Ghuzlān had direct access to the Red Sea and knew how to use this location for foreign trade over long distances.

Excavations at Tall Hujayrāt al-Ghuzlān have been ongoing since 2002 under the auspices of the ASEYM project (Archaeological Survey and Excavation in the Yutum and Magass Area). The Aqaba region lies at the fringe of attention of Near Eastern Archaeology and Egyptology in terms of international research. It remained barely noticed for a long time.

Tall Hujayrāt al-Ghuzlān was founded during the Chalcolithic period (also known as the Copper-Stone Age, 4100 to 3600 BC) and is therefore, with the exception of minor finds in the neighbouring Negev Desert, the oldest verified human settlement in the Aqaba region. The organisation of the settlement is very surprising, because – in contrast to what is normally anticipated for this period – it does not reveal a simple, rural settlement, but comprises multi-room buildings of at least two storeys. In other words, Hujayrāt al-Ghuzlān was “planned” and built in a very limited space. Various sized rooms indicate a variety of functional units, accessed via a complex network of routes. Already in the Chalcolithic Hujayrāt al-Ghuzlān was afflicted by a number of earthquakes. The result was that rooms had to be stabilised by additional walls and the settlement came more and more to resemble a labyrinth. And still people continued to live and work here. These ancient earthquakes have left behind them special research conditions for the archaeologists. Numerous buildings remain standing,

What did houses and other buildings look like in the ancient Hujayrāt al-Ghuzlān settlement? The architecture in the north of the complex allows deep and revealing insights.

some up to four metres high; even pillars and alcoves within the walls can be found.

This unusual situation is reminiscent of antique Pompeii. In contrast to the latter, however, it appears that there were no earthquake victims in Tall Hujayrāt al-Ghuzlān. At least, no buried skeletons have yet been excavated. Instead, human jaw bones are found repeatedly in the settlement’s fill courses. It is currently not clear whether these are the remains of burials or an ancestral cult, in which parts of the bodies of the dead were interned inside the houses, similar to the situation in Celtic settlements.

An evaluation of the architectural history of the findings in the north of the complex could help to expose the original appearance of the settlement: large, round pillars, all belonging to an earlier building phase than the walls erected later, were located at regular intervals. They once carried a now non-existent roof structure. This shows, then, that Tall Hujayrāt al-Ghuzlān was characterised by astonishingly large, almost monumental room units. These large-roomed structures differ from the small structures in the rest of the settlement.

The settlement was enclosed by a wall, built of large wadi pebbles, which was renewed during the course of the settlement’s history. It very probably formed part of the site’s defences. However, it is still not clear who the population were defending against. The only

The excavation map for the Tall Hujayrāt al-Ghuzlān site in Jordan.

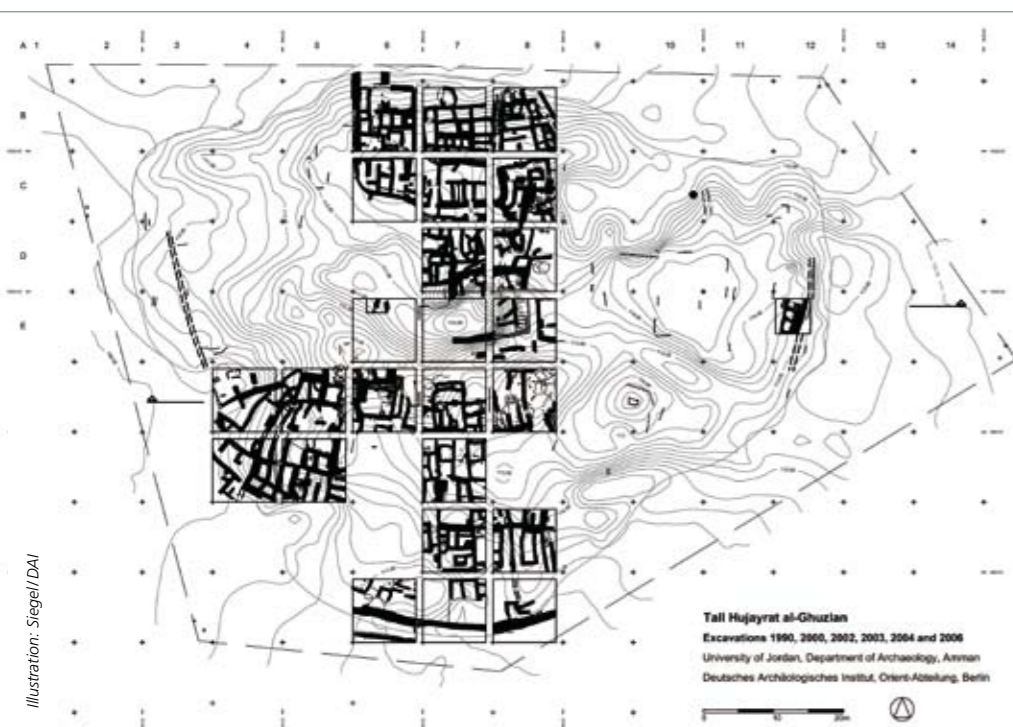




Illustration: Schmidt/DAI



Illustration: Becker/DAI



Illustration: Becker/DAI

Impressive witnesses: Wall decoration including two ibexes; a human with raised arms can be seen below the front ibex. Centre: A thousand beads, many made from mollusc shells, discovered in a clay vessel. Bottom: Stones of various sizes were once used to reduce copper ores and mill cereals.

weapons found are in the form of mace-heads. A fragmented stone bowl with a geometrical zigzag decoration links the settlement to the ritual site of Khirbet Rizqeh, in a side arm of Wadi Rum, where human figures, carved in stone, were erected in a circle. The enormous number of copper crucibles and casting moulds in Tall Hujayrāt al-Ghuzlān is witness to the fact that the place could not have been just a common residential settlement. Instead, life there was very heavily oriented around the production of copper ingots and finished products.

Trace element analyses have shown that the ore originated either in nearby Timnah or in deposits in Wadi Feinan, approximately 100 kilometres north of the site. It was then processed in Tall Hujayrāt al-Ghuzlān. Fist-sized grinding stones were used and, in particular, variously sized granite milling stones. Traces of green colour can still be recognised on some stones, a result of continuous rubbing by copper ores.

The ingots were intended for export. Pre-dynastic Egypt was one of the favoured trading partners. Ingots whose shape and size exactly match the casting moulds used at Hujayrāt al-Ghuzlān were found in a settlement in the Nile delta. In exchange the site on the Gulf of

Aqaba received valuable Egyptian stone vessels and rare Nile mussels. The find of a small clay figurine is unique in the southern Levant to date. Thanks to stylistic comparisons it can also be identified as an Egyptian import.

The population primarily ate goats and sheep, and only a few bones derive from wild animals, and domesticated and wild donkeys. The botanical remains show that the climate during the Chalcolithic was practically the same as today's. Agriculture relied on flax, barley and wheat. However, the region's aridity did not and does not lend itself to agriculture. Rainfall is infrequent and unreliable, flash floods following storms present a hazard to fields and may even destroy them completely. The population of Tall Hujayrāt al-Ghuzlān therefore utilised the subterranean groundwater flow below the wadi for irrigation purposes. An irrigation system used to divert water to the fields is located outside of the settlement.

Another peculiarity: conspicuous wall decorations embellish a building complex in the west of the settlement. They include handprints on four walls, and representations of animals and people, made by pressing the fingertips into the wet wall plaster. The most common motifs are ibexes. It is possible that the site's modern name is derived from these, probably inadvertently visible, representations. "Hujayrāt al-Ghuzlān" can be best translated as "rooms of the ibex". All decorations are found in the south-west of Tall Hujayrāt al-Ghuzlān and signify that this area had a special function.

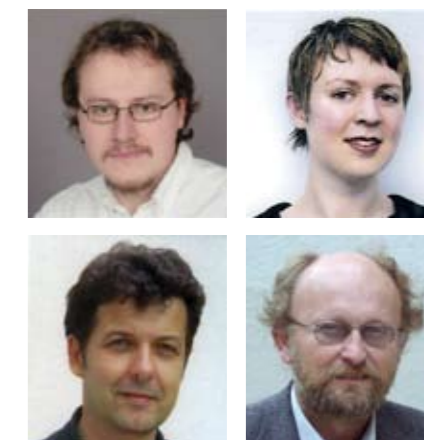
The 2006 to 2010 excavations specifically addressed this question

and unearthed spectacular finds. A clay representation of a horn was found in the immediate vicinity of the wall decorations. The piece must have originally belonged to a larger sculpture and it is assumed that it was related to the wall decorations. The situation is similar for five miniature vessels found at the foot of a decorated adobe brick wall. The unfired condition of the objects and the decoration on only one side rules out profane use. The complex of rooms to the east was excavated in 2010; a unique stone has been recovered. A total of eight square to sub-trapezoidal characters were engraved on it. There is no apparent interpretation of the characters as yet, but it appears to be closely related to the special use of this area. A sealed vessel containing several thousand beads, the smallest of which were only approximately one millimetre long, was located below the base of the walls in this room. This ensemble is regarded as one of the most spectacular finds ever in the region.

Numerous skulls and horn core fragments, which are evidently related to the parietal art images, were recovered not far from the vessels, below one of the wall decorations. The frequency of such extraordinary finds underlines the importance of this part of the settlement. Further excavations in this area hold the promise not only of exceptional finds, they may even help uncover what is so "special" about this area. Does a prehistoric temple perhaps lie hidden in the west of Tall Hujayrāt al-Ghuzlān?

In the Oriental Department of the German Archaeological Insti-

tute (DAI) the results of the 2006 to 2010 excavations are being evaluated and prepared for publication. One thing is certain: the oft-cited wheel was not invented in Tall Hujayrāt al-Ghuzlān and the site unquestionably was located at the edge of the ancient Egyptian world. And yet, it was involved in decisive technological innovations, highly relevant to the cultural history of the eastern Mediterranean. Possibly – the many points of contact with the Nile valley seem to indicate this – the site was even an important link in a chain of inter-related factors, which together contributed to the rise of the advanced Egyptian civilisation in the fourth millennium BC.



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The project is run in cooperation with the University of Jordan, Amman, the German Mining Museum (Deutsches Bergbau-Museum), Bochum, the Lübeck University of Applied Sciences and the Bishkek Geological Institute, Kyrgyzstan.

www.dainst.org/Aqaba

Walter Hömberg

Talent Scouts and Proofreaders

Editors are always in their authors' shadows, and yet no work of literature could be published without them. A new study provides a sociogram of this profession, analysing their daily duties and the way in which they are perceived by themselves and others.

Editors at publishing houses are communication professionals about which very little is known. "If things go according to plan, the authors are the people who take the spotlight. Whatever happens, the editors remain in the shadows", writes Marcel Reich-Ranicki. Christoph Selzer, one of the editors we interviewed, tells the story of an editor who went to a civil registry office, where he was asked to state his profession. The clerk at the registry office, however, had never heard of "Lektor" (Engl.: editor), so she wrote the similar-sounding word "Elektriker" (Engl.: electrician).

This far-reaching anonymity leads to confused perceptions of the profession. In common parlance, an editor in the first place is a reader. Anyone who thinks, however, that an editor at a publishing house is paid good money to spend the whole day perusing edifying reading matter, is mistaken. Nowadays, editors must be part publisher, part author, part sponsor and part marketing professional – and of course – clairvoyant. As project and product managers, they have become veritable "Jacks of all trades". The image of a bespectacled



Illustration: Stephanie Hofschaefer/pixelio.de

A cliché rather than reality: Reading is just a small part of an editor's daily duties.

bookworm who discovers new literary treasures by poring over submitted manuscripts, however, persists. One thing is certain: the blatant stereotype of the constant reader sitting contemplatively in a hushed room has probably never been accurate. So what are editors really like?

Answers to this question are provided by a study which has been being carried out since 2005 by the Journalism Department at the Catholic University in Eichstätt. The investigation comprised three survey phases: a postal questionnaire which was sent to 1344 German book publishers (and achieved a response rate of 36.3 percent), a phone survey carried out among 311 full-time editors, and in-depth verbal interviews with a select group of 16 editors from different types of publishing firm. The study's structure, implementation and results are documented in detail in a recently published book, the second edition of which has just been released.

The following text describes some of the results from the editors' telephone survey. One thing that is immediately apparent is that editing is a female profession. Almost two-thirds of the survey respondents are female. The average age of respondents is early forties. The level of formal education is very high: 91 percent have completed a degree, while one in five has achieved his or her doctorate. Their qualifications are overwhelmingly in linguistic and literary subjects, with German Studies predominating. While degrees in art history and cultural studies and history were also particularly popular choices, degrees in the natural sciences and technology were also mentioned.



Illustration: Olaf Heiling

Red pens and dictionaries: Editors must be masters of German spelling and punctuation.

Just under half of all respondents acquired the specific skills required of a professional editor through an internship or job shadowing programme. A good third have completed practical training in a publishing house. In just one-fifth of cases, respondents' professional editing careers were preceded by professional training in a publishing house, bookstore or library. Thirty-seven percent had attended a specific editing course. No single method of getting started in this profession, therefore, stands out.

Four out of five editors who participated in the survey are full-time, permanent employees. They have, on average, around ten years of relevant professional experience. Their actual working hours clearly exceed 40 per week. Taking only the full-time editors into account, the average was a good 45 hours. Most of these work in the non-fiction and textbook sector.

On average, an editor reads 21 manuscripts for print each

year. Only a very small percentage of work actually published is submitted to publishers unsolicited, although many publishers receive more unsolicited manuscripts each month (around 24) than an editor can prepare for print in a year. "The unsolicited manuscripts we receive are generally from dilettantes. It's quite touching," says Tobias Heyl from the Hanser Verlag publishing house. Hans-Ulrich Müller-Schwefe of the Suhrkamp Verlag adds: "I don't think the flow [of manuscripts] will ever cease. Once you've been an editor for a while, you begin to think that everyone's a writer."

What are a modern editor's main daily duties? Despite all the prophecies of doom that editors in publishing houses are increasingly becoming product managers, traditional editing activities are still right at the top of the "most common tasks" lists. Author mentoring

is the most commonly mentioned task, with almost 96 percent of respondents reporting that this was something they did “often”. In second place, cited by 91 percent of respondents, is working on manuscripts. Almost level in third and fourth places are writing explanatory texts (86 percent) and evaluating the suitability of manuscripts for publication.

The task which takes fifth place in the rankings is sure to be one seldom associated with the stereotypical perception of the editor as bookworm: that of drawing up and

monitoring schedules (81 percent). Developing new book ideas, correcting grammar, and calculating costs follow. An editor’s day, therefore, involves a mixture of traditional editing tasks and business activities.

What do editors aim to achieve through their work? The responses show that editors overwhelmingly see themselves as serving the interests of their publishing houses. They also want to serve their authors’ interests, promote development and provide information. This clearly illustrates the

Janus-faced nature of the editor’s work: it involves meeting the often opposing needs of publisher and author, and of doing almost equal justice to their interests.

A glance at the lower rankings shows that the more service-based attitudes are followed by middle-of-the-field desires for achieving higher circulation and sales figures, communicating new ideas, and attaining personal fulfilment. The lower places are reserved for promoting literature, entertaining readers and helping them unwind, and for providing them with orientation and counsel-

Having passed the editor’s desks, the latest releases will, ideally, keep the book market busy. This image shows the literature desk at the Deutschlandfunk radio station with, from left to right, Hubert Winkels, Hajo Steinert and Denis Scheck.



Illustration: Deutschlandfunk/Bettina Furst-Fastré

ling. Right at the very bottom is the aim of making a lot of money.

As it turns out, the average mostly net salary for a full-time editor is rather a modest one: the average is €2,000, with women earning considerably less than men. On average, editors have a lower income than other communications professionals, such as journalists or public relations officers, for example.

Job satisfaction, on the other hand, seems high, with editors having little to criticise. One of the editors surveyed emphasised the author-reader mediatory function fulfilled by editors: “I really enjoy having the time to mentor the development of a book and in, a way, to act as midwife to it. This, for me, is the classic definition of an editor: to act as a mediator between author and reader and to ensure that knowledge is transferred from one to the other” (Stefanie Aulbach, J. D. Sauerländer’s Verlag).

Editors particularly value their relationships with their co-workers. 95 percent of respondents said that they are “fairly satisfied” to “very satisfied” with this aspect of their work. Editors also rated highly the ability to manage their own time. Furthermore, there is a high level of satisfaction with their own professional qualifications, even though the options available for attaining further qualifications seem sufficient to just half of respondents. The security provided by the profession is evaluated as average. The level of remuneration, the advancement opportunities, time available for core activities and workload are, on the other hand, considered less satisfactory.

Editors consider publishers and CEOs the main influences on their work. These are followed by

programme directors and editors-in-chief, and – in third place – the authors. Fourth place is taken by “Other publishing-house employees” and – in fifth place – the “Readers, customers and target audiences”. The literature critics, reviewers and literary agents are described as having the least influence.

Which skills and abilities are particularly important for editors? The answers to this question indicate that a knowledge of German language and grammar is considered the most important skill. The ability to work as a team is ranked as the second most important. Specialist knowledge is ranked only third, followed by the ability to handle stress and a knowledge of relevant computer programmes. Carlos Westerkamp of the Ullstein Verlag summarises the requisite skills as follows: “Editors must have a feel for literature, and a feeling for styles and trends. They should be flexible, resilient, communicative, and both open to discussion and strong-willed.”

The generally high level of career satisfaction remains unaltered by the fact that the editors surveyed expect the publishing industry and their work as editors to be increasingly shaped by economic activity. Editors expect to increasingly represent the business interests of their publishing houses, to spend more time planning, coordinating and delegating, and to require more technical and business skills. The survey participants also, however, assume that the traditional core activities, like mentoring authors and working on manuscripts, will continue to be part of their remit.

This is the first time that empirical data on the editing profession in the German-speaking

world has been collected. Editors are talent scouts, trendsetters and proofreaders – all rolled into one. There can be no doubt as to the importance of the role they play in the book production process. Having said that, the significance of the various tasks involved in publishing has changed markedly over the past few years – and will continue to change in the future.

If nothing else, the production of best sellers, changes in the book trade and increasing media competition have contributed to the increasing significance of public relations and advertising. The sales market and the limited attention span of potential readers are hotly contested areas. Without the editors’ passion, this profession, which attracts many high qualified idealists, would be inconceivable. Passion for the profession must not, however, be allowed to obscure the need for economically sound action.



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Walter Hömberg: Lektor im Buchverlag. Repräsentative Studie über einen unbekannteren Kommunikationsberuf. Carried out in collaboration with Susanne Pypke and Christian Klenk. Second, revised edition. Constance, UVK Verlagsgesellschaft 2011.

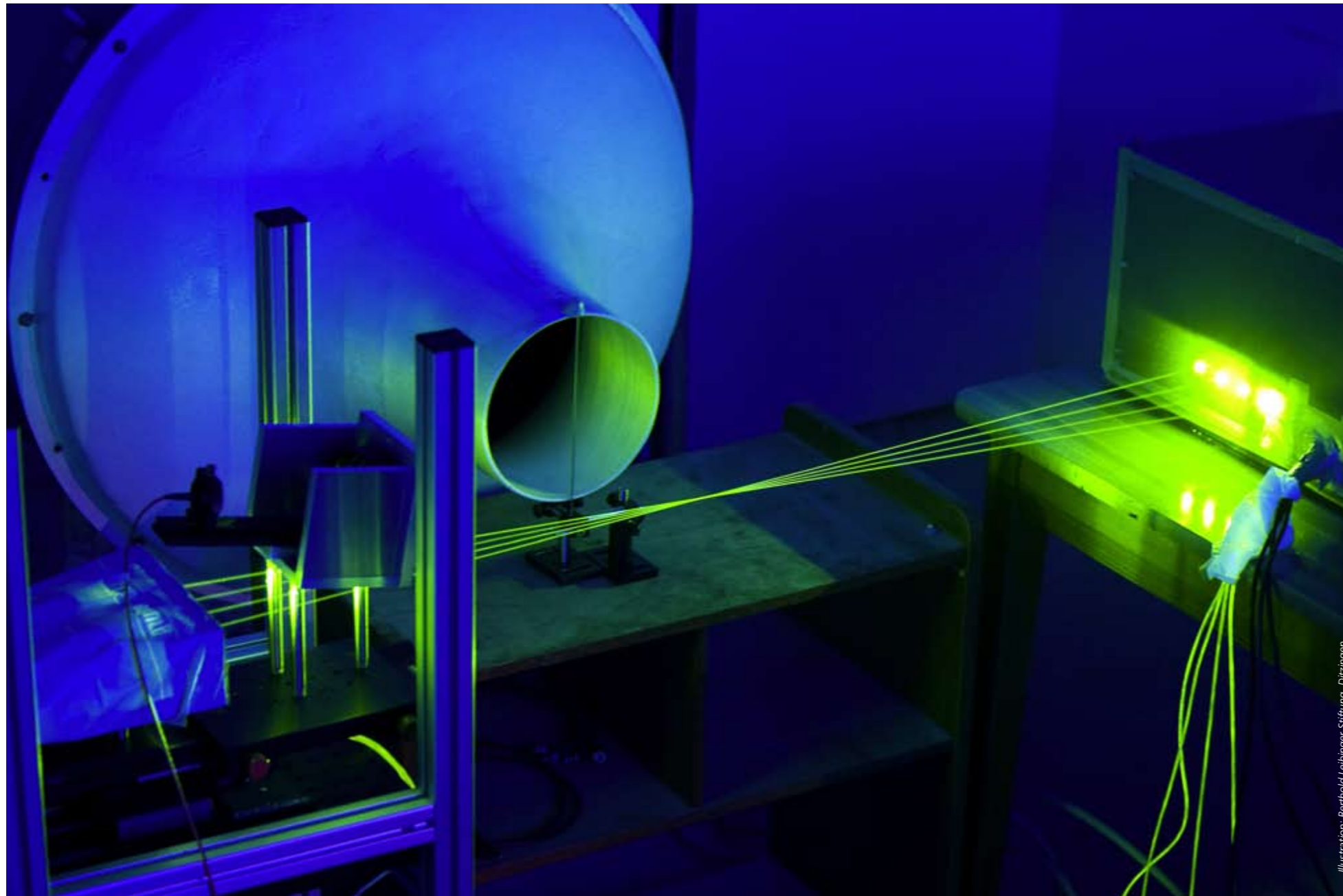


Illustration: Berthold Leibinger Stiftung, Ditzingen

Jürgen W. Czarske

A Spot of Turbulence

Measuring technique: An innovative technique enables non-intrusive, high-precision measurements of microscopic and macroscopic fluid flows. The laser Doppler velocity profile sensor has huge potential for applications in science and technology.

Panta rhei – everything flows: fluid flows are found everywhere and have an important role to play in many areas of nature and technology. Developers of automobiles and aircraft are both interested in achieving the lowest possible drag noise and stable handling. The key to this is understanding the complex interactions between a physical body on the one hand and the fluid on the other.

A precise understanding of flow mechanisms permits aeroplane wings to be designed in a way that they have a low drag force, which saves fuel and exhaust emissions. Likewise in the interior of aircraft engines, you can observe the complex interactions of the compressor turbine blades with the gases that flow through them. This influences the efficiency, the noise generation, and not least the reliability and lifetime of these engines.

It is exciting when flows become turbulent, in other words, when complex spatial and temporal variations occur. Even today, the understanding of turbulent flows is one of the last unsolved riddles of classical physics. Vortices occur on a large scale in the atmosphere; as is well-known they can grow to become tornadoes in extreme cases. But vortices also occur on a smaller scale, for example in pipelines, around the rotor blades of turbomachines, or even on hard-disk drives in computers. Due to the fact that the simulation of turbulent flows is so complicated and expensive that even super-computers run up against their limits, modern metrological methods frequently offer the only possibility for visualising and understanding these flows.

The non-intrusive measurement of flows is based on the Doppler effect, which is familiar from acoustics.

The sound of the siren on a vehicle that is approaching or driving away seems higher or lower than a stationary vehicle, respectively. When it comes to the optical Doppler effect our everyday experience is less helpful, but the principle is the same. In this case, a high-resolution measuring technology is required to determine the optical Doppler frequency shift because of the much higher speed of light compared to sound.

The history of velocimetry using the laser Doppler technique started in 1964 – only four years after the laser was invented. Generally, to measure the velocity of a flow, laser light is scattered by particles in the fluid (meaning a gas or a liquid). Particles which have a typical diameter in the micrometre range and which can follow the flow without any significant “slippage” (difference in velocity) are thus added to the fluid. The Doppler frequency shift of the scattered light is then measured using electronic digital signal processing techniques. Nowadays, the laser Doppler measurement technique is an established procedure for the investigation of flows. However, it has not achieved the desired resolution of turbulence on the micro scale (millionth of a metre).

This is where an invention by the TU Dresden comes in. Several laser waves of different colours (and thus light wavelengths) are cleverly superimposed in the measurement field. The flow velocity is then calculated with a high spatial resolution by measuring the Doppler frequency shifts using digital signal processing technology. The world’s first “laser Doppler velocity profile sensor” with micrometre resolution was awarded the Berthold Leibinger Innovation Prize in 2008. The innovative optical

sensor permitted enhanced insights into turbulent flows and led to a renaissance in laser Doppler measuring technology.

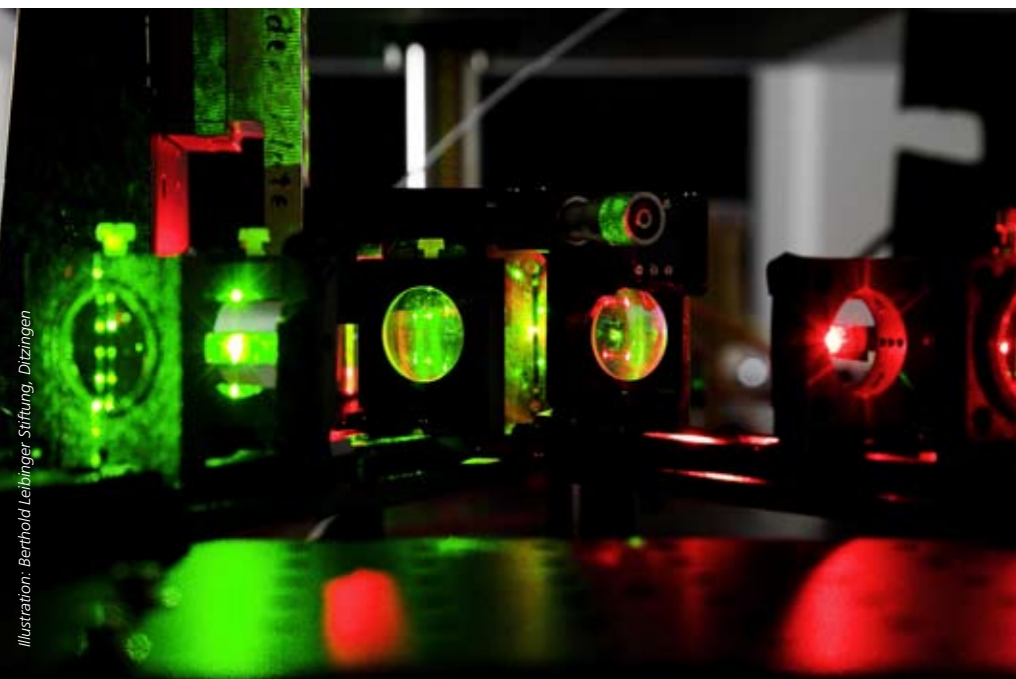
Flow processes are also of great importance on computer hard-disk drives. Hard-disk drives are magnetic data storage devices which at present have a capacity of up to four terabytes (four trillion bytes). A byte represents one letter or one decimal number and corresponds to eight binary digits (bit), which have the value 0 or 1). At present, disks with a magnetisable layer rotate at a speed of up to 15,000 revolutions per minute inside the hard-disk drive. To achieve a high performance capability and thereby a high storage density, it is necessary to have a very small clearance between the disk and the head for reading and writing data on the disk. Modern read-and-write heads float

about 10 nanometres (billionth of a metre) above the disk supported on an air-bearing, which is created by the friction between the air and the rotating disk surface (the so-called ground effect).

This air flow is therefore utilised for the storage function. But there are also air flows which cause noise and undesirable vibrations of the disk. Turbulent flows occur in the gap between the rotating disk and the housing. With the laser Doppler velocity profile sensor, it was possible to measure the vortex flows in this tiny gap.

It is of decisive importance here that the air flow from the centre to the edge of the disk interferes with the flow that circulates in the gap. It is assumed that vibrations of the disk are excited by these turbulent shear flows. In future, new design features will be used to reduce such problems.

Several laser wavelengths (light colours) are used simultaneously to measure microfluids, for example in electrochemistry.



The measurement of flow velocities can also be used for the quantification of fluids. In the Federal Republic of Germany, about 22.5 percent of total energy consumption is covered by natural gas. Every year about 90 billion cubic metres of natural gas is forwarded to end consumers, which means that reliable volume information is essential for both consumption and planning. This is the responsibility of a test station operated by E.ON Ruhrgas AG in cooperation with the national metrology institute of Germany, PTB (Physikalisch-Technische Bundesanstalt). In view of the enormous quantity of gas and its distribution, there is a need for precise flow measurement, for example using optical methods.

High-precision measurement is necessary for commercial enterprises as well as for the state and the government. This conclusion was already reached by the Greek philosopher Plato (427–347 BC), who declared that “the arts of measuring and numbering and weighing come to the rescue of the human understanding – there is the beauty of them – and the apparent greater or less, or more or heavier, no longer have the mastery over us, but give way before calculation and measure and weight. And this, surely, must be the work of the calculating and rational principle in the soul.”

The idea and aim of the new measuring technology is non-intrusive, high-precision measurement of the velocity of natural gas flows and thereby to calculate the volumetric flow rate. The laser Doppler velocity profile sensor is predestined for this task. The velocity profile of the natural gas flow was measured just after it passed through a specially-shaped nozzle at a pressure

of 50 bar (gas pressure 50-times higher than the atmospheric pressure). It was possible to measure the natural gas flow with a resolution about one order of magnitude better than the conventional laser Doppler measuring technology. The flow rate can thereby be measured with higher accuracy, which opens new possibilities for other applications – for controlling dosing processes in medicine, for instance, or for the analysis of coating processes in electrochemistry.

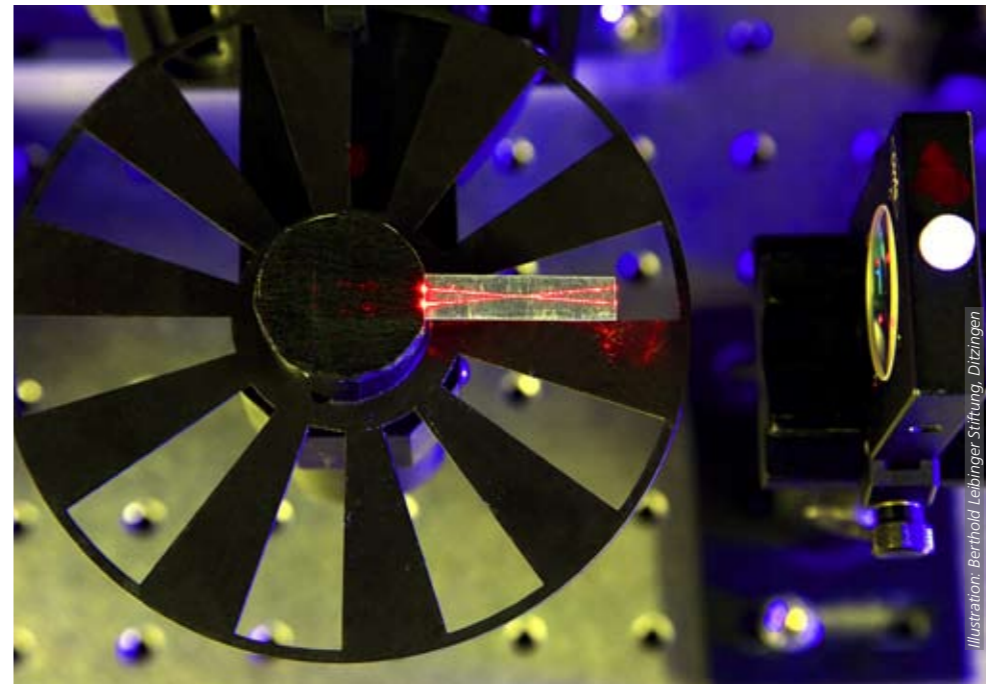
Of fundamental importance: Calibration of the laser Doppler measuring technology.

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Apart from flow measurement, the new optical Doppler sensor is also suitable for the measurement of technical objects. In this case, the light diffusion caused by rough surfaces is used to measure position and velocity. Optical sensors have obvious advantages: contactless measurements can be made with very high precision. A huge range of sensors are available for measuring the surfaces of non-moving objects.

However, if precise measurement of fast-moving objects, such as turbine blades with rotational speeds in the supersonic range, is required, commercially available sensors are hardly an option.

The ability to investigate rotor dynamics is of great importance when it comes to minimising losses and wear. One example is the width of the gap between the rotating blades and the housing of turbomachines. In order to achieve a high level of efficiency, the gap should be as narrow as possible to reduce secondary flows. On the other hand, the turbine blades must not touch the housing under any circumstances, even under fluctuating operating conditions caused by the influence of temperature, pressure or centrifugal forces. This could destroy the machine. Systems for regulating the width of this gap will be important for the turbomachines



of the future. One prerequisite is a sensor that precisely measures the width of the gap. These requirements are met by the novel laser Doppler sensor.

Scientists took gap-width measurements using a so-called transonic centrifugal compressor (a turbomachine operated in the supersonic range, which performs fluid compression in a radial direction), belonging to the German Aerospace Center (DLR, Cologne, Germany), the blade tips of which move at supersonic speeds. Precise measurements were taken at rotational speeds of up to 50,000 revolutions per minute and tip blade speeds of 2110 km/hour. Thanks to the high time resolution, it was also possible to document rotor vibrations with the laser Doppler sensor, so that the vibration characteristics could be analysed. In conclusion, an innovative laser Doppler sensor is now available for laboratory and industrial measurements. Its main contribution could be a lasting improvement to energy efficiency and the operational reliability of turbomachines.



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The new laser Doppler velocity profile sensor was recognised with the Berthold Leibinger Innovation Prize in 2008.

<http://eeemp1.et.tu-dresden.de>

We are faced with countless decisions every day: should I buy a new, modern television today, or would it be better to save my money for tomorrow? Do we eat the tempting filet mignon or instead opt for the low-calorie, healthy salad? Do we choose this butter or that bar of chocolate? In addition to economic researchers and psychologists, brain researchers have for years been exploring issues related to decision making as well. They use their modern methods to study brain functions in order to better understand human behaviour. The field of neuroeconomics formed at this interface, an area of study that is attempting to clarify the biological fundamentals of the human decision-making process on an interdisciplinary level.

Are organic products really worth more to us – and can this “added value” be verified in the brain? The labelling of food products influences the decision-making behaviour of consumers. Seals on food products are intended to evoke positive associations, indicate high quality and thereby influence purchasing behaviour. We examined whether the organic seal on food products changes the willingness to pay and how this effect can be understood in areas of the brain.

For this purpose, we asked the test persons to refrain from eating for four hours prior to the experiment. This was intended to increase the willingness to purchase food. In addition, for one half hour after the experiment, they were only permitted to eat food purchased during the experiment. The test subjects came to us in the laboratory and, following a detailed orientation, were placed in the magnetic

resonance imaging (MRI) scanner. Using video goggles, they were offered food while in the scanner that they could purchase at a price they themselves specified.

Some of these products were labelled as organic products, some as regular food products. The test persons saw bananas, apples and noodles and used response buttons, which they held in their hands, to express their willingness to pay for each. After about half an hour, during which the accompanying brain activity was recorded with the aid of functional magnetic resonance imaging, this part of the experiment was concluded and the test persons could again leave the MRI scanner. This was followed by surveys on attitudes towards organic products, purchasing behaviour, health awareness as well as various personality characteristics.

At the end of the experiment, five products purchased by the test persons during the experiment were chosen at random, which they could take home with them. A total of 35 people participated in this experiment. The analysis clearly showed that the test subjects were willing to pay more for organic products – on average, these products were worth 40 percent more to them. The brain also showed increased activation for organic products in the areas of essential importance for decision-making behaviour. The strength of the activation in the “ventral striatum” even corresponded to the actual purchase frequency of the test persons. This means that the stronger the activation by organic products in this area of the brain, which is considered part of the “reward system”, the more often the test persons purchased these products in



Bernd Weber

Smart Decisions

Whether in the car showroom or in front of the supermarket shelf, we are faced with making selections every day. Using imaging techniques, the field of neuroeconomics hopes to better understand the biological fundamentals of this behaviour.

daily life. Building on this study, we are planning to examine whether product labelling also changes the perceived flavour. In other words, does the “diet product” label cause the product to taste worse (or different) to the customer?

This example shows that consumer behaviour is an exciting and important topic in neuroeconomic research. Contrary to what is sometimes suspected by the public, this represents only part of the new research discipline. By exploring the biology, we are able to gain a sense of the diversity among people and their decision behaviour. In the same situation, one person might choose option A and the other might select option B. The situation is even more difficult: in a given instance, the same person might decide, for example, to trust another person and give him his money. But after viewing a film on fraud, he prefers to keep the money himself. What is the basis for the main differences in behaviour, whether for individuals or between people?

In recent years, there have been continued improvements in better understanding the neurological fun-

damentals of social and economic behaviour, particularly though the combination of theories and methods from various disciplines. Are there genetic influences on complex social behaviour? If yes, how strongly are these pronounced, how do they interact with environmental influences, upbringing and personal development?

Discussed intensively in recent years is the relationship between cognitive and non-cognitive abilities and economic preferences (and, thus, economic and social success). Neuroeconomic research can make an important contribution here by combining knowledge and methods from psychology, genetics and cognitive neuroscience with so-called econometric methods of economic research and with variables such as educational performance, income and satisfaction with life.

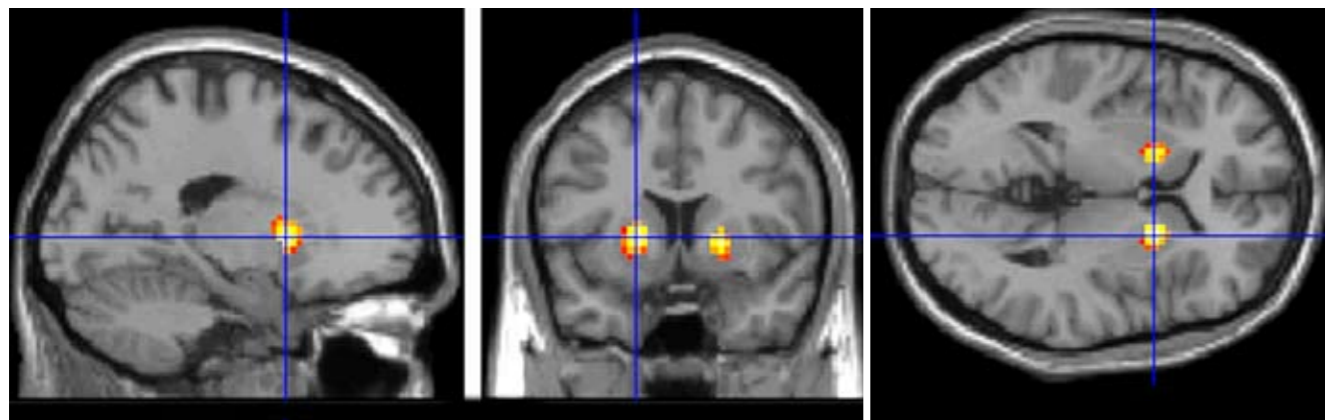
On the other side, medical research also profits from the results. In the area of psychiatric illnesses, experiments from classic behavioural economics and from neuroeconomic research are used to study the neural fundamentals of illnesses such as schizophrenia, depression, autism and dependencies. Autists, for example, show reduced

trust in economic games. Administering oxytocin – a neuropeptide – on the other hand, increased the trust in other test subjects in an economic game; initial studies showed promising results here.

Another important area examines economic preferences across the entire life span. In the USA, a large part of neuroeconomic research is financed by the National Institute of Aging to clarify decision-making processes in old age. Unlike the wealth of findings on young adults – attributable mainly to the student population in the studies – there exists much less knowledge on decision-making processes at old age. Given the rapid change in demographics in Western industrialised countries, this represents a large and important challenge.

Initial studies indicate a clear effect on ageing in the decision-making process: for example, that older people respond less to award incentives and learn less quickly from positive feedback; older people also appear to be more adverse to risk when making decisions. Here, too, brain areas related to risk processing were more strongly activated and

A look into the brain: Where and how brain areas are activated interests neuroeconomists in their experiments.



In MRI scanners: The test person is placed in decision-making situations using video eyeglasses.

contributed to reduced willingness to accept risk.

The future of neuroeconomic research lies in the intermeshing of the various disciplines. Large cohorts, usually with origins in the health sector, are currently being studied worldwide together by economic researchers and neuroscientists with respect to economic behaviour to describe genetic, hormonal or environmental influences on economic preferences. Together with the German Institute for Economic Research (DIW) in Berlin, we, too, were able to perform pilot studies in representative groups. Relatively small and targeted laboratory tests

with the aid of imaging techniques will accompany and supplement these studies.

Through the increased understanding of biological fundamentals (and, as a result, the biologically-based limitations) of human decision-making behaviour, classic economic models will also be influenced and expanded. Lastly, this topic is of high socio-political relevance. By understanding how we, as people, are influenced – coming back to the example on purchasing behaviour given at the beginning of the article – we, as consumers, can better understand our own behaviour and perhaps even change it. But this knowledge can also be used politically to create an eco-

nomical environment that takes human biology into account.



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Natalija Novak

What Causes Itching Sensations?

Neurodermatitis is one of the most common and agonising skin diseases. The emergence and course of this chronic disease are affected by a number of factors. Molecular mechanisms that interlock like the pieces of a jigsaw puzzle are of particular importance.



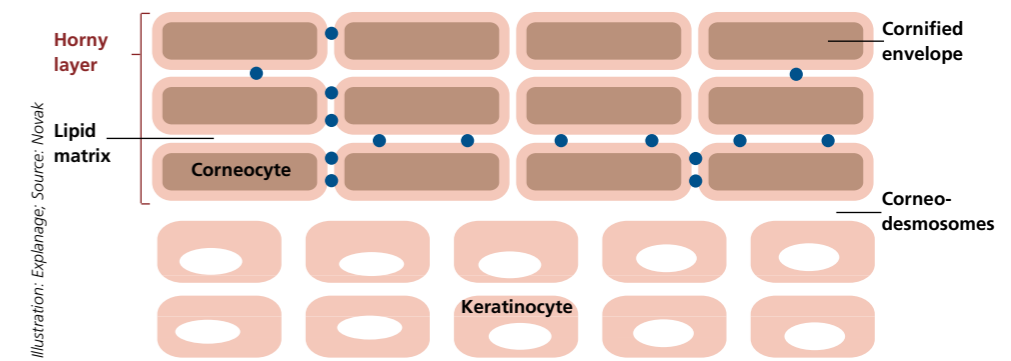
Illustration: Bob Sacha/Corbis

Dry, red skin, scaly patches of eczema, agonising itchiness: Neurodermatitis, also referred to as atopic dermatitis, is one of the commonest skin diseases there is – and its causes are a complex but fascinating puzzle. Put simply, it is a chronic inflammation of the skin with recurrent acute eczema attacks. Although the disease can be mild in some cases, in others it is accompanied by severe attacks of itchiness, often at night, which can result in sleeplessness and general loss of performance, resulting in significant stress.

One in five toddlers in Germany is currently affected by atopic dermatitis. For many, the condition disappears by the time they reach puberty, but it persists into adulthood for between 1 and 3 percent of sufferers, and in some cases it even develops during adulthood. Depending on the stage of life in which it develops, the eczema may be in the face, in the folds of the elbows or knees, or on the head, neck or hands. But what is the exact cause of this skin condition?

A large number of factors are known to be involved in causing neurodermatitis – both in its emergence as well as in the flaring up of the inflammatory lesions. These so-called trigger factors include skin bacteria, viruses and fungi, allergens in food and in the air, psychological stress and mechanical irritation due to sweating or certain fabrics.

Genetic predisposition is another factor worth mentioning. For instance, the risk of a child developing neurodermatitis is twice as high if either of its parents suffers from an atopic disease. Other atopic diseases apart from neurodermatitis – all of which are characterised



The brick wall model of the skin barrier: The cells in the upper horny layer, the corneocytes, are like bricks. If these cells are shed, more cells, the keratinocytes, migrate up from below, forming a horny layer. Any interference with this horn-creation process favours neurodermatitis.

by immunological hypersensitivity reactions – include hay fever and asthma. If both parents are affected by an atopic disease, the risk of a child developing neurodermatitis increases threefold.

What complicates matters, however, is that – unlike classical hereditary diseases – it is impossible to link this hereditary component to a specific genetic attribute. Rather, it seems that several genes interact with each other as well as with environmental factors.

One factor that is presumed to be a key element in this complex disease process has, however, been identified by recent research. Its name is filaggrin. This is a special protein, produced by certain skin cells, the keratinocytes. Changes in the filaggrin gene can, it seems, interfere with the barrier function of the epidermis. Remarkably, these mutations are particularly frequent in neurodermatitis patients.

A brick wall is a good model of the epidermal barrier, which acts as a protective shield for the body (see graphic above). A decisive factor in

understanding this is the fact that the uppermost layer of “bricks”, the horn cells (corneocytes) in the skin are constantly being shed and the “wall” being rebuilt by keratinocytes below, with which they are replaced. On their way upwards, the keratinocytes are transformed into fully keratinized corneocytes.

This is where filaggrin comes into play. The protein is essential for a horny layer (the stratum corneum) to be able to form around the cells and maintain the integrity of the skin barrier. The breakdown products of the filaggrin, the filaggrin peptides, are also involved in regulating the water content and the pH of the skin, both of which play an important role in the function of the skin. The disease thus begins early and is particularly severe in neurodermatitis sufferers where mutation of the filaggrin gene is observed.

But what has the interference with the integrity of the skin barrier got to do with the chronic inflammation that is so typical of atopic dermatitis? One simple answer lies in the fact that if the horny layer is

damaged, it is easier for allergens and pathogens to penetrate the skin, where they can then trigger immunological inflammatory processes. And immune defence does indeed make a significant contribution to the protection provided by the skin. These immune mechanisms are often altered in patients suffering from atopic dermatitis. The weakening of the skin barrier is also accompanied by immunological misregulation.

We now know that both defects in innate immunity as well as acquired immunity can play a role in the emergence of neurodermatitis. The innate immune system is an evolutionarily very old and efficient system of defence mech-

anisms which provide protection against hostile signals in the environment.

For example, special cell receptors, so-called pattern recognition receptors, on skin cells are used to detect characteristic components of pathogens. For some of these receptors (including the toll-like-receptors 2, 4 and 9) we now know of modifications and construction flaws in the associated genes, which are observed more commonly in sufferers of atopic dermatitis than in the general population. Some of the patients could thus be more susceptible to bacterial or viral infections due to deficient signal recognition by the innate immune system. In addition to this, we also

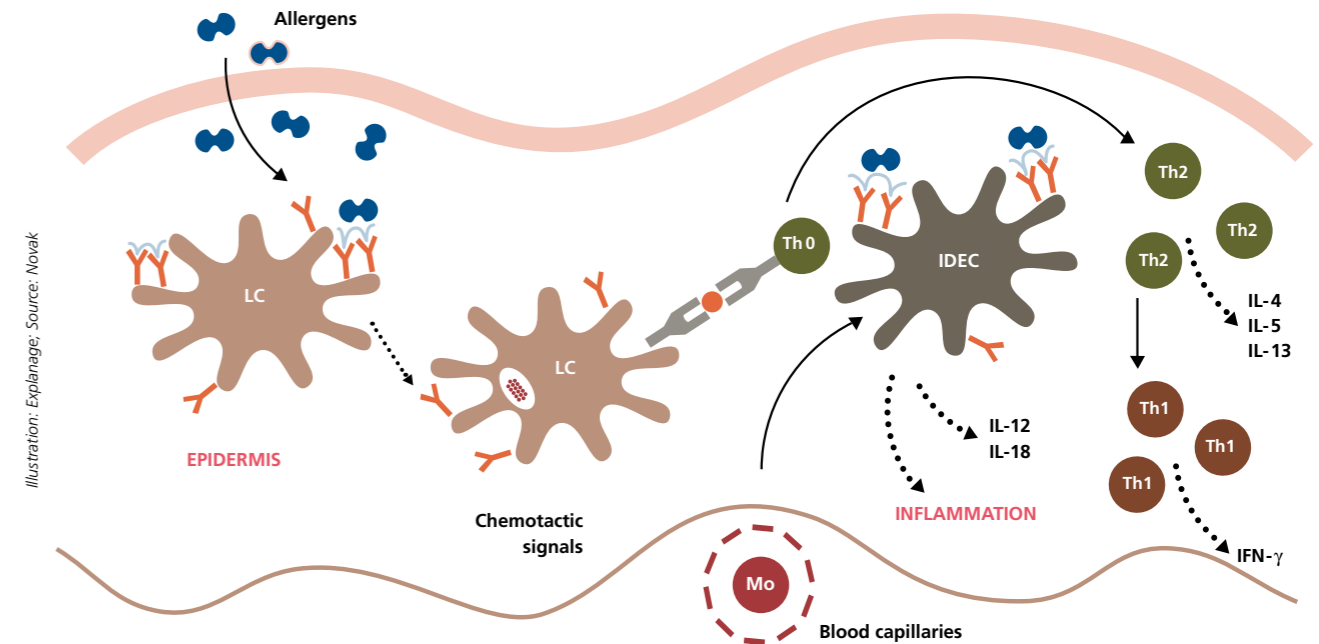
know that levels of the antimicrobial peptides (such as the beta-defensins or cathelicidin) formed naturally by skin cells are lower in neurodermatitis sufferers.

Another factor that is probably even more important for the disease process are the dendritic cells. These immune cells have fine branches called dendrites located in the upper layers of skin and act as the body's immunological sensors, latching on to antigens that have penetrated the skin, moving to the lymph nodes and alarming their immunological partners, the T cells. In this way the dendritic cells form an interface between the relatively simple innate immune system

A coin-shaped, partly scabby outbreak of eczema. Neurodermatitis is accompanied by recurrent bouts of eczema in various parts of the body.



Illustration: Bob Sacha / Corbis



Schematic diagram of the acute eczema attacks that accompany neurodermatitis: At the beginning of the complex inflammation process are the Langerhans cells (LC), which absorb allergens and activate specific T cells (Th0). Subsequently, the balance between LC, inflammatory dendritic cells (IDEC) and various types of T cells with their specific messengers (IL) decide on the course of the disease.

and the highly adaptable acquired (adaptive) immune system, which is primarily controlled by the T cells.

The classical example of dendritic cells in the skin are the "Langerhans cells". During an acute attack of eczema in a neurodermatitis sufferer, the Langerhans cells take up allergens and activate specific T cells as well as using signalling substances to attract other dendritic cells in the upper layers of skin. These then reinforce the inflammation response using highly active immune transmitters (see graphic above).

Another immunological mechanism that is not yet fully understood – known as IgE autoreactivity – contributes to the disease becoming independently established. This refers to the phenomenon in atopic dermatitis sufferers where certain antibodies can actually attack the skin itself. One possible reason for this is the fact that frequent

scratching of itchy skin also allows proteins that are very similar to the body's own proteins ("molecular mimicry") to penetrate the skin. Antibodies produced by the immune system to fight these antigens are thus also able to attack the sufferer's own skin. This could, at least in part, explain why some patients develop serious attacks of the disease without any evident external trigger.

It is clear, however, that in spite of their complexity, all of these mechanisms are merely part of the disease process. There are lots of other factors that are already known to be involved in neurodermatitis, although the varying combination and weighting of the various causes leads to the progression of the disease varying greatly from patient to patient. The aim now is to go beyond the standard treatments currently available to

develop individualised therapeutic approaches for neurodermatitis, tailored to each individual patient. The increasing knowledge available on its development mechanisms will help to reach this goal.



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Rembert Unterstell

The Turtle Code

When the specific illuminates the general: Palaeontologist Walter Joyce uses spectacular finds to look deep into the history of evolution and the Earth / From Yale to Tübingen

Perhaps we should refer to him as a modern explorer. Since his childhood, he has travelled between the Old World and the New. He is also a time-traveller, exploring the evolutionary history of our planet. He is Dr. Walter Joyce, palaeontologist and scientific assistant at the Geological Institute at the University of Tübingen. In 2009, he transferred from Yale University in the USA to the Eberhard Karls University of Tübingen in Swabia, Germany.

We arrange to meet the 38-year-old at his office. He's between trips and is in a convivial mood. He appears affable and easygoing, communicative and humorous, despite having just weathered a media frenzy: his completely unexpected, but spectac-

ular, dinosaur fossil find has caused his work to hit the headlines. "Dinos sell", he says.

Joyce and his colleague, Tyler Lyson, discovered a 40 centimetre long horn belonging to a prehistoric titan (*Triceratops horridus*) in the Hell Creek Formation in Montana. Extensive analysis revealed it to be the youngest Cretaceous-era dinosaur fossil ever found. This has resulted in a momentous insight: these giants of old cannot have died out before the end of the Cretaceous period. Instead, they may have been eradicated by the often-discussed meteorite impact and a subsequent wave of extinction 65 million years ago.

Other species, including turtles, also survived the catastrophe,

and Joyce found evidence of these in Montana. Due to the dino hype, however, the media was uninterested. Turtles may have survived thanks to their cold-blooded lifestyle, which includes periods of summer aestivation and winter hibernation. "It's entirely possible that they literally slept through the meteor impact," says Joyce. André Kostolany, Germany's stock market guru, would have liked that.

Joyce's speciality is the evolution of fossil turtles. Even during his student days, he was fascinated by these primitive vertebrates and their environment. Fully aware of the implications of his decision, he decided to study turtles, knowing that they are "not exactly career-advancing", at

least, not outside an extremely small specialist community.

In his palaeontological dissertation, Joyce shed light on the murky depths of turtle origins. Using taxonomy and phylogenetics to piece together evidence, he was able to clarify the relationships between "basal turtles" and re-draw their family tree. One key finding: "The stem lineage of turtles is terrestrial." This means that, during the Triassic period, which began 250 million years ago and ended 200 million years ago, turtles lived predominantly on land. It was not until the Jurassic period (which extended from 200 million years ago until approximately 145 million years ago) that they entered the water. Contrary to expectations, the first turtle species were clearly terrestrial. In 2005, Joyce's studies earned him the Society of Vertebrate Palaeontology's Romer Prize.

Joyce considers himself to be a "palaeontologist who combines methods from morphology, taxonomy and biological classification and uses them to answer geological questions." He has, for example, been able to address the controversial question of how turtles developed their characteristic carapaces.

Joyce is happy to show visitors photos of prepared fossils on his Mac. At such times you sense not just his enthusiasm, but also what drives him – the allure of being a detective and a burning "desire to discover new connections."

Walter Joyce was born in 1972 in Milwaukee, Wisconsin, and grew up in Erlangen, Germany. His enthusiasm for geology was awakened when, as an eight-year-old boy, he discovered a trilobite (a hard-shelled arthropod). He began his studies in geology and palaeontology at the University



Up close: A turtle skeleton. Comparative sections help Joyce compile detailed descriptions.

of Erlangen before his American roots took him down a transatlantic path. Returning stateside, he headed first to the University of Kansas and then to Louisiana State University, ending up at the University of Texas at Austin.

In 1999 he completed his studies in Erlangen and made the leap to Yale, earning his doctorate at the fabled Ivy League University in 2004. Looking back, he is grateful for the "first-class educational foundation he received in Germany and for the early scientific independence he attained in the USA."

After achieving his doctorate, Joyce served as the collections manager of vertebrate palaeontology at Yale's Peabody Museum of Natural History. Even in this position, he pursued a mobile lifestyle – fieldwork and museum visits took him, among others, to Argentina, Canada, Russia and Switzerland.

In Tübingen, Joyce is currently working on his DFG-funded project, "The Evolution of Neck Retraction Mechanisms in Basal Turtles". All modern turtles can be divided into two main categories: the "crypto-

pires", which can retract their heads into their shells; and the "pleurodires", which draw their heads sideways under their shells in a horizontal "S" movement. Joyce now aims to study prehistoric turtles to determine how and when this evolutionary development took place.

In a second DFG project, he intends to use "taxonomic methods" to study the many thousands of turtles found by a German-Chinese team in the Late Jurassic Qigu Formation of China's Xinjiang region in 2008. The palaeontologist estimates that this is "the richest deposit of fossil turtles in the world". Here, Joyce aims to detail the turtles' morphological variations, describe unknown species, and determine their place in the phylogenetic tree. This is a mammoth undertaking, and what awaits him at the end is still unclear. There are, however, indications that this explorer's research will continue to provide food for discussion.

Dr. Rembert Unterstell
is Publishing Executive Editor of "german research".

A glimpse into a mass grave of fossil turtles. Right: In his element – Walter Joyce at Tübingen University's Geological Museum.



Ferenc Krausz and Thorsten Naeser

Diving Deep into the Atom

When all notions of time lose their validity: Using laser flashes lasting billionths of a second, physicists are trying to follow the ultrafast movements of quantum particles in real time. The experiments in the Laboratory for Attosecond Physics are already making possible increasingly precise insight into matter. And the light pulses are getting even shorter.

Photographers know the principle well: for sharp images of rapid movements, a short exposure time must be selected. Otherwise, in a photo of an athletic competition scene or a fast-moving child, for example, it may only be possible to identify silhouettes.

As researchers began to “photograph” movements of atoms and molecules during chemical reactions in the early 1990s, this had very little to do with photography in the traditional sense. But the principle remained the same: a short exposure time is needed in order to capture sharp images. Atoms and molecules change within femtoseconds. A femtosecond is a millionth of billionth of a second. Thus, it was necessary to find an exposure technique that was also only femtoseconds in duration. Laser technology was used for this purpose. Researchers worked with light flashes that were only femtoseconds long.

But, in spite of groundbreaking successes and the Nobel Prize, awarded to Egyptian Ahmed Zewail in 1999, key questions remained unanswered. What exactly happens within the electron shell that sur-

rounds every atomic nucleus? How can the movements of individual electrons be followed? Is there perhaps a way to examine our notion of atomic structure using “images”? It was speculated that processes on this still-smaller level transpired even faster than the relatively sluggish atoms and molecules.

The hunt for shorter exposure times and the associated, even smaller fractions of a second was on. In 2001 the Vienna University of Technology finally succeeded in dividing the femtoseconds yet again by 1000. For the first time, light flashes were created here that lasted only 650 attoseconds. An attosecond is a billionth of a billionth of a second.

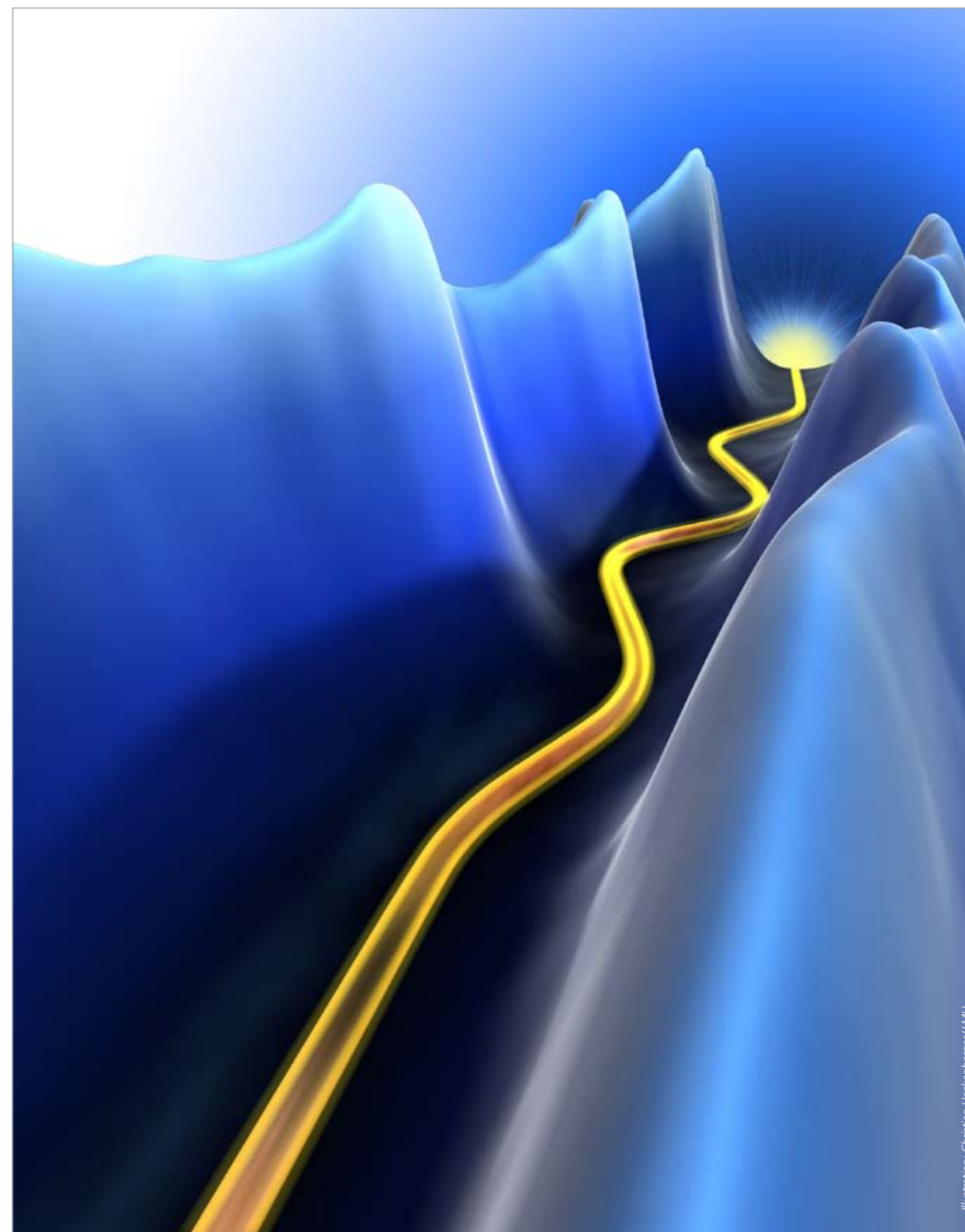
Since 2003 the research group has resided at the Max Planck Institute of Quantum Optics (MPQ) and the Ludwig Maximilian University of Munich (LMU). There, researchers work in the Laboratory for Attosecond Physics (LAP) to break time into even smaller pieces. In 2008 the team succeeded in shortening the flashes of light to 80 attoseconds. With this, we gain increasingly precise insight into

world of quantum particles, many areas of which are still a mystery.

In this world, even holes pulsate. We were able to show in 2010 that the “absolute void” has a life of its own. In the experiments, a team working under research group leader Dr. Eleftherios Goulielmakis sent laser pulses from the visible part of the spectrum into krypton atoms. The light pulses, with a duration of less than four femtoseconds, removed one electron from the outer shell of each atom. After a laser pulse had knocked an electron out of an atom, the atom became a positively charged ion. At the location where the electron left the atom, a positively charged hole was formed. From a quantum mechanical standpoint, this free space in the atom continued to pulsate – with a so-called quantum beat.

It was possible to record, i.e., quasi photograph, the pulsation

Artist depiction: The photoemission of two particles from different orbitals, only attoseconds in duration, is recorded by a light wave (yellow line). The captured images (blue surfaces) show the delay in the initial movement of the particles.



with a second pulse of light. This pulse lasted only 150 attoseconds and was in the extreme ultraviolet part of the light spectrum. It was determined that the location of the hole in the ion, i.e., the positively charged location, cyclically changed back and forth between an elongated lobe shape and a compact, contracted shape within approximately six femtoseconds. With that, we succeeded for the first time – as was reported by the journal “Nature” in August 2010 – in directly recording the change of charge distribution in an atom.

With another research project, we follow the tracks of Albert Einstein. The exceptional physicist discovered photoemission more than 100 years ago. When light strikes atoms, their electrons are excited. If sufficient energy is supplied, the particles leave the atom. The discovery of the photoelectric effect revolutionised physics: quantum mechanics was born. The excitation and photoemission of electrons in atoms remains one of the most interesting and important phenomena in quantum physics. It was assumed that the movement of

the electrons in the atom begins as soon as the light beam strikes. This time is defined as the zero point in the excitation of electrons.

Using an ultra short-time measurement technique, the team examined this assumption. For this purpose, the researchers directed light pulses onto neon atoms. It was determined that the electrons, located on different orbits – the orbitals of the atoms – and excited simultaneously by the light pulse, exit the atoms only after a time delay of a few tens of attoseconds.

The new findings contradict the previous assumption that the electrons exit the atom immediately upon impact of the light pulse. “Thus, one of the electrons leaves the atom before the other”, sums up Dr. Martin Schultze. It was thereby possible to demonstrate and comprehend that electrons hesitate briefly after being excited by light before they leave the atom.

For the theoretical physicists working with Vladislav Yakovlev, it was important to determine the cause of this delay. The researchers were ultimately able to confirm the effect with their calculations. Their findings showed a delay of only five attoseconds, however. The cause of this discrepancy likely lies in the complexity of the neon atom, which, in addition to the nucleus, consists of ten electrons. “The computational effort for the entire atomic model, taking into account all interactions between all electrons, exceeds the capacity of today’s supercomputers”, emphasises Yakovlev.

Nevertheless, the experiments revealed the likely cause for the “delay” of the electrons. We assume that the electrons interact not only with their atomic nucleus, but

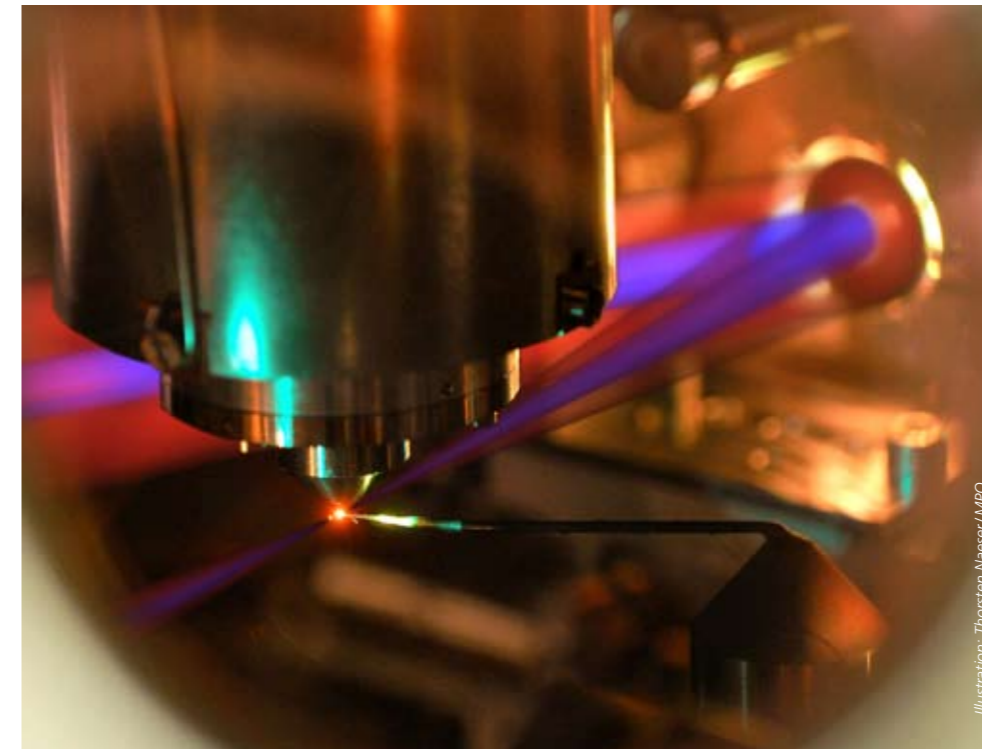


Illustration: Thorsten Naeser/MPQ

Measurements with the aid of innovative technologies in a vacuum chamber.

that they also affect one another. The electron-electron interaction may lead to a small delay before the electron that is knocked loose by the incident light waves is able to break free from its fellow electrons and leave the atom. With the new insight into the microcosm, the teams working with Schultze and Yakovlev have pried further secrets from the microcosm. The findings mean important insight into the interactions of electrons in atoms – and, thus, into a world that is largely not understood even today.

Also studying the racing electrons in the LAP team is Dr. Matthias Kling. In his research, the young researcher and leader of an Emmy Noether independent junior research group of the DFG is focussed not on the behaviour

of individual particles, however. He is studying their collective movements. Such “swarm-like” movements are also referred to as “plasmons” by experts. “Using attosecond techniques, plasmons can be directly observed as well. Their dynamics typically play out on time scales of up to 100 attoseconds”, explains Kling. He and his group have specialised on plasmons in nanoparticles of gold and silver. The physicists are now studying how these particles interact with light. To do this, they are directing femtosecond laser pulses at the gold particles. In this way, they excite the electrons in the material, causing them to vibrate. An attosecond flash of light is then used to record and analyse the behaviour of the negatively charged particles. Real-time films of ultra-short processes in the microcosm

can thereby be created. “Gold nanoparticles are used, for example, in solar cells to increase the efficiency”, explains Matthias Kling. “We want to understand exactly how the light affects the electrons. This will allow us to use the nanoparticles much more efficiently and in other ways.”

Plasmons are particularly well suited for use in so-called fibre optic cable electronics. Here, plasmonic fields could be used to drastically accelerate data processing and transmission. The system could operate at the frequency of light waves, which would be an increase by a factor of one million over current technologies.

Attosecond technology is still far from reaching its limit. In the coming years, we will shorten the flashes of light even further. And, the light will offer even more precise insight into the multifaceted microcosm. It is already clear: it is a deep and exciting dive into the inner life of atoms.



Prof. Dr. Ferenc Krausz is director at the Max Planck Institute of Quantum Optics where he heads the Department of Attosecond and High-Field Physics; at the same time, he is chair of experimental physics at LMU Munich.

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www.attoworld.de

In the attosecond laboratory: The two physicists Matthias Kling (left) and Sergey Zherebtsov discuss the structure of the “attosecond beamline”. Their goal is to follow the movement of electrons from one quantum state to the next in real time.

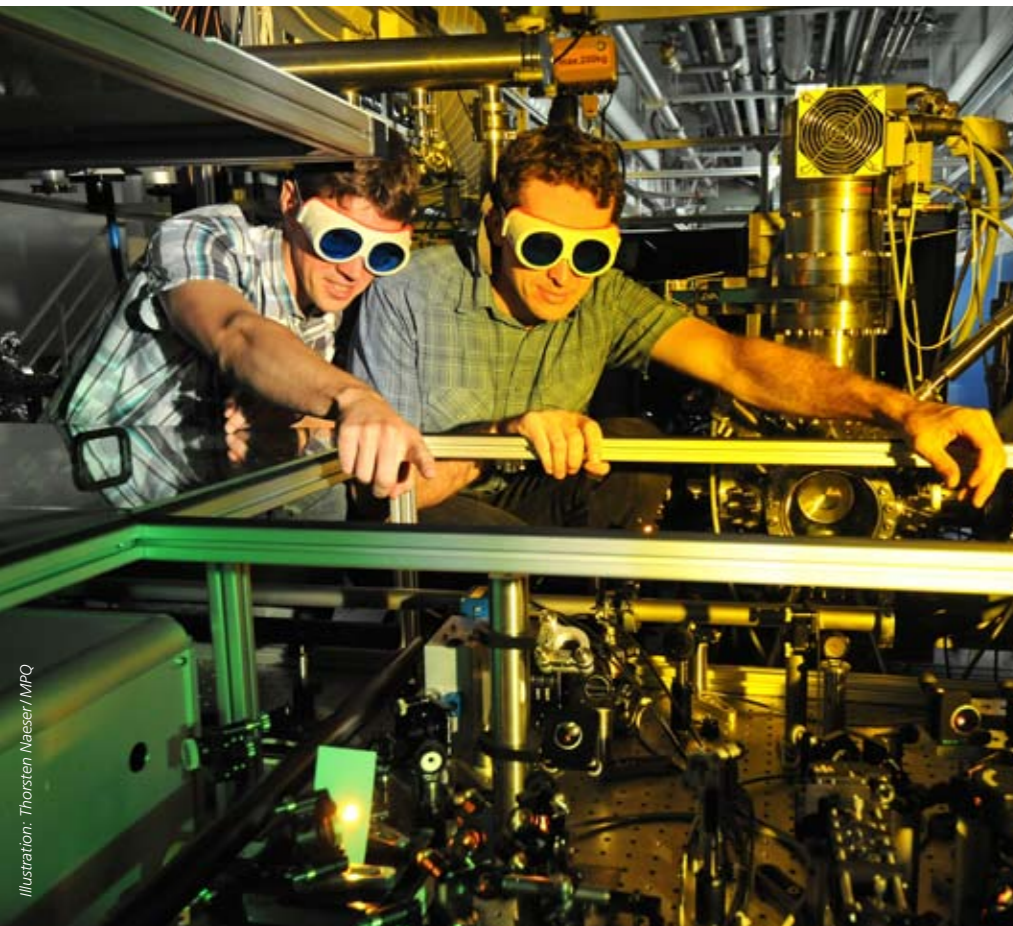


Illustration: Thorsten Naeser/MPQ

The Deutsche Forschungsgemeinschaft

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the areas of basic and applied research. Particular attention is paid to promoting young researchers. Researchers who work at a university or research institution in Germany are eligible to apply for DFG funding. Proposals will be peer reviewed. The final assessment will be carried out by review boards, the members of which are elected by researchers in Germany in their individual subject areas every four years.

The DFG distinguishes between the following programmes for research funding: In the *Individual Grants Programme*, any researcher can apply for financial assistance for an individual research project. *Priority Programmes* allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A *Research Unit* is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In *Central Research Facilities* there is a particular concentration of personnel and equipment that is required to provide scientific and technical services.

Collaborative Research Centres are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of twelve years. In addition to the classic Collaborative Research Centres, which are concentrated at one location and open to all subject areas, the DFG also offers several programme variations. *CRC/Transregios* allow various locations to cooperate on one topical focus. *Cultural Studies Research Centres* are designed to support the transition in the humanities to an integrated cultural studies paradigm. *Transfer Units* serve to transfer the findings of basic research produced by Collaborative Research Centres into the realm of practical application by promoting cooperation between research institutes and users.

DFG Research Centres are an important strategic funding instrument. They concentrate scientific research competence in particularly innovative fields and create temporary, internationally visible research priorities at research universities.

Research Training Groups are university training programmes established for a specific time period to support young researchers by actively involving them in research work. This focusses on a coherent, topically defined, research and study programme. Research Training Groups are designed to promote the early independence of doctoral students and intensify international exchange. They are open to international participants. In *International Research Training Groups*, a jointly structured doctoral programme is offered by German and foreign universities. Other funding opportunities for qualified young researchers are offered by the *Heisenberg Programme* and the *Emmy Noether Programme*. In so called *Reinhard Koselleck Projects*, the DFG supports especially innovative research undertakings by outstanding scientists and academics.

The *Excellence Initiative* aims to promote top-level research and improve the quality of German universities and research institutions in the long term. Funding is provided for graduate schools, clusters of excellence and institutional strategies.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals for scientific instrumentation. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

Another important role of the DFG is to provide policy advice to parliaments and public authorities on scientific issues. A large number of expert commissions and committees provide the scientific background for the passing of new legislation, primarily in the areas of environmental protection and health care.

The legal status of the DFG is that of an association under private law. Its member organisations include research universities, major non-university research institutions, such as the Max Planck Society, the Fraunhofer Society and the Leibniz Association, the Academies of Sciences and Humanities and a number of scientific associations. In order to meet its responsibilities, the DFG receives funding from the German federal government and the federal states, as well as an annual contribution from the Donors' Association for the Promotion of Sciences and Humanities in Germany.



Audacious, trenchant and high-spirited – Margie Kinsky and Georg Roth from the “Springmaus” ensemble brought their own particular brand of improvisation comedy to the stage of Bonn’s Wissenschaftszentrum shortly before the 2011 holiday season. Their humorous offering, “Mit élan durch die Module” [Through the modules with élan], captivated the audience from the very beginning. With sketches full of sly humour and playfulness, the DFG thanked the 750 employees at its Head Office for their commitment and hard work during the year and for the success of its two major projects: élan, the DFG’s electronic proposal processing system, and the modularisation of its programme portfolio.

Impressum

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