NEWS 2/2018

COMPLEXITY SCIENCE HUB VIENNA

Rock art in the Parque Nacional Serra da Capivara (PiauÍ, Brazil). There is a war of opinions going on about its actual age. © Verena Ahne

Dear friends of the Hub!

In spring I had the opportunity to travel to Brazil as a science journalist. I went to Rio to prepare a Memorandum of Understanding between the Centro Brasileiro de Pesquisas Físicas and the Hub (we are happy to cooperate more closely in the future!) before travelling on to Piauí, a state in the Northeast of the country. During this journey I talked to researchers from all kinds of fields. Like scientists everywhere in the world, they were passionate about their respective subject. Be it statistical mechanics for complex systems, explained to me by CSH External Faculty member Constantino Tsallis; the prehistoric rock art in Piauí; or the fragility of this state's unique ecosystem, they would expound their questions and answers with shiny eyes. Without exception though, they would also bring up a deficiency syndrome the whole scientific community in Brazil is suffering from, as a petition signed by more than 82,000 scientists shows: a syndrome provoked by President Temer's cuts on Brazil's →federal funding for science and technology to the lowest level in modern history.

Saving on science not only makes the life of present scientists miserable: It hurts society as a whole. Those who still dare to step into science will inevitably leave without acceptable opportunities. This again raises dependencies from others: other countries or (certainly never unselfish) companies.

In Europe, we can – so far – be grateful for an environment that appreciates science. Nevertheless, one can always do better. One of the masterminds of an US think tank, Brian Arthur, told me what makes great institutions successful (see the Q&A section below). To grow exceptional ideas, he said – the really great stuff, like quantum theory or the INTERNET –, it needs, above all, a lot of freedom. Freedom from bureaucratic constraints that always take a toll on free thinking. And: the freedom to be daring.

We work hard to create such an environment at the Hub. May benevolent forces be with us!

Verena Ahne, *Head of Knowledge Transfer*

Verena (left) with complexity scientists Constantino Tsallis, Roselie Wedemann, Fernando Nobre, and Evaldo Curado at the CBPF (Centro Brasileiro de Pesquisas Físicas).

D4Dairy: Big Data for healthier cows

Dairy farming goes digital – and the Hub deals with the data.

The Hub is going to get into cows now. How come? In June the Austrian Research Promotion Agency FFG–the national funding agency for industrial research and development in Austria–decided to support a project proposal put together by the Austrian Cattle Breeders' Association (ZAR). The project, with the beautiful acronym "D4Dairy" ("Digitalisation, Data integration, Detection and Decision support in Dairying") connects dozens of partners from agricultural organizations and farmers through industry and smaller size enterprises down to scientific institutions. "In pilot studies, the ZAR has built up an infrastructure to measure and document all kinds of parameters in dairy farms," explains Peter Klimek, key researcher for the Big Data analysis of the project. "They gathered huge amounts of data already, including environmental factors in stables, plus all veterinary diagnoses for two million cows or the genome sequences of 50,000 cows in Austria." One of the industry partners, for instance, provides special sensors to be swallowed by the animals. Once in the rumen, the sensors constantly transmit information like changes in body temperature. This allows farmers or veterinarians to react early to a possibly beginning illness.


Olga Saukh


Peter Klimek


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The stable as a "sensor landscape"

Data is where the Hub comes into play. First, data are–and will be–gained from diverse sources in different formats. The lack of communication between the systems does not only give a headache to farmers, who see themselves forced to double or multiple (manual) recording; diverging data sets make data analysis at a large scale difficult, too.

"Every company uses its own standards, and sends the data to different servers," says Olga Saukh, the CSH–TU Graz key researcher for the "Digitalisation, data integration and decision support" part of D4Dairy. "As the systems are not plug'n'play, we have to integrate the data for further use: check for monocompliance, calibrate, structure the data gaining processes." In addition, Olga will expand future data collection in a meaningful way to cover specific research questions defined by Peter and colleagues. In doing so, punctual measurements will increasingly be replaced by constant data streams.

For the well-being of cows – and humans

Peter, for his part, is looking forward to a new dimension of medical data analysis: "For humans, such comprehensive datasets are still missing," he knows – one reason being data security concerns, "a minor problem with animals," as he smilingly adds.

The major output of D4Dairy should be the improvement in the health and well-being of milk cows. From the perspective of complexity science though, Peter wants to come to a better understanding of the interplay between nature and nurture in general. Big Data, says the complexity expert, will help disentangle genetic, environmental and individual factors that contribute to either health or disease in a subject. "With 83 percent of their genes being identical to ours, cows are genetically quite close to humans," Peter says. "The methods and prognostic models we are going to develop and test in D4Dairy will be applicable to human data as well."

The project D4Dairy was submitted by the Austrian Cattle Breeder's Association ZAR within the framework of COMET (Competence Centers for Excellent Technologies). COMET is an Austrian science program launched in 2006 to foster the cooperation and knowledge transfer between small, medium and large enterprises, universities, Universities of Applied Sciences, competence centers and research institutions.

Women might profit more from social networks than men

Is there a relationship between the number of men and women actively using the Internet and general socio-economic gender inequalities, e.g., the access to health, education, or political participation?


David Garcia

"It is hard to get unbiased survey data to compare the digital gender divide across countries," says CSH Faculty member David Garcia. "We tested

if we can overcome this problem with very large datasets."

Together with an international research team, David generated an anonymous dataset with statistics about all men and women in 217 countries who are registered with or actively using Facebook – more than 1.4 billion accounts altogether. With these data the scientists calculated what they call the Facebook Gender Divide (FGD): the difference between the number of men and women using their Facebook account. As shown in the map, most countries (in blue) are very close to gender equality. Reddish colors show a positive FGD–that is, a higher proportion of males using Facebook.

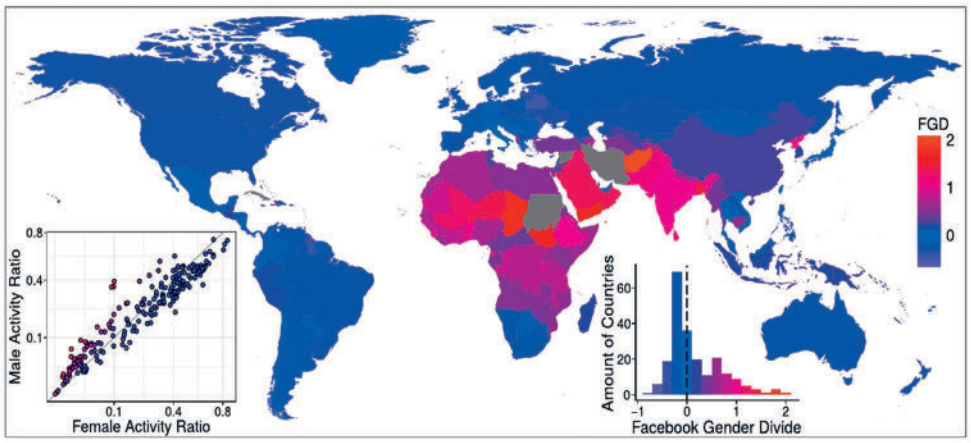
Most of the countries with more men using Facebook than women are located in Africa and South West Asia. "We tested if this can be explained by socio-economic factors of gender inequality," says David. To do so, the scientists validated their data with the four indices of gender equality used by the World Economic Forum: economic opportunity, education, health, and political participation. Non-gender-based standard socioeconomic indices like population size, GDP, or Internet penetration served as a control.

The results indeed show an association between the Facebook Gender Divide and other measures of gender inequality. "For instance, we found evidence that women might benefit more from a general adoption of Facebook in a country than men," David points out. These so-called network externalities (also known as Metcalfe's law) mean, simplified: the more people actively use Facebook, the more people profit from it. The paper of David Garcia and colleagues from *Universidad Carlos III de Madrid* shows that this positive effect is slightly larger for women.

"Our results allow us to speculate that social media can be an equalizing force that counteracts other barriers by providing access to greater economic opportunities and social capital," the article's authors state. "In a similar way as mobile phones increased the life quality of fishermen in India, social media might work as a digital provide that helps disfavored groups (...) in access to ICT and in adoption of social media technologies."

This is no explanation of the underlying causes, David makes clear. "But we now have further evidence that cheap and easily accessible social media data can be used for the social good." For example, to understand social phenomena such as gender inequality.

The article →Analyzing gender inequality through large-scale Facebook advertising data appeared in PNAS, June 19 (2018).



The map (© David Garcia) shows countries colored according to their Facebook Gender Divide. The blue color shows countries that are close to gender equality in Facebook. The red scale shows countries with positive FGD, that is, with a higher proportion of males on Facebook. The FGD has a value below zero when women tend to be more active on Facebook than men, a value close to zero for equal activity tendencies, and a positive value when men in a country are more active on the social network than women.

Statistics need correction – but the right one

Real data can be erroneous. In statistics it is essential to use clean data without wrong values, like so-called "outliers" obtained from wrong measurements. However, if correct anomalous measurements are omitted, the results are flawed.


Jan Korbel

"It is generally quite difficult to distinguish between correct data and outliers," says Jan Korbel, one of the Hub's young talented theoreticians. Take temperature measurements as an example. If weeks of heat are interrupted by a single exceptionally cold day, the outlier could be the product of a broken meter. Or just as well another sign of the growing number of extreme weather events that humans produce by incessantly heating up the planet – quite the opposite message.

"Of course, we only want to get rid of data that distort our results," Jan explains. "The problem is: You very often don't know the reason for the outlier." Statisticians come up with different solutions to deal with this anything-but-trivial problem appearing in complex systems. Jan and his Turkish colleague Mehmet N. Çankaya recently introduced a novel method, based on robust statistics. "To put it in simple words, we kind of average the underlying distribution and the outliers," Jan explains the, as he puts it, "quite nice" statistical innovation.

The scientists tested the concept with weather data from Grytviken, a small settlement on the island of South Georgia, not far from Tierra del Fuego and Antarctica, of which they knew the reason for the temperature spikes. They contaminated the long-term measurements with outliers, corresponding to recent extremely warm temperatures. And, as Jan proudly says, a big smile in his face: "Compared to other approaches, our model produced more robust results to the presence of outliers."

Jan and Mehmet's article →Least informative distributions in maximum q-log-likelihood estimation appeared in Physica A: Statistical Mechanics and its Applications.

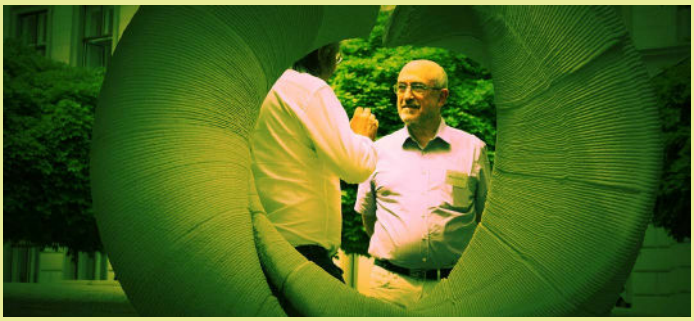
HUBLIFE

COMPLEXITY SCIENCE HUB VIENNA

Check out our →Event Calendar for weekly talks by our members, associates and visitors from home and abroad, or find upcoming events, talks and visitors on the front page →www.csh.ac.at after scrolling down.

Working groups in the inner courtyard of Palais Strozzi discussing how to organize City Olympics. © Verena Ahne

The past months have been full of inspiring events. In early May, for instance, we held a preparatory brainstorming workshop, together with ETH Zurich, about future →**"City Olympics."**
"We are far off reaching the goal of a sustainable planet," co-organizer Dirk Helbing maintains, worried about challenges like rising temperatures, loss of biodiversity, mass migration, conflicts or even terrorism. "These problems seem all related to a lack of sustainability. And they are so big already that they will re-rail our system as a whole." This analysis is at the beginning for the City Olympics idea. "We are in an urgent need of a lot of bottom-up engagement," Dirk said. "Competitions naturally raise efforts – and they are fun!" The aim of the Games is to let evolve self-organizing systems: positive forces that empower and mobilize citizens and communities from the bottom-up. The representatives of cities and different climate action movements who participated in this first meeting were already enthusiastic and drove back home with large agendas. We are looking forward to the far bigger follow-up workshop in September at the Hub!



Janós Kertész from Central European University at the External Faculty Meeting 2018, seen through a Johann Berger sculpture. © Verena Ahne

Later in May Stefan Thurner invited our international and national faculty to the first **CSH External Faculty Meeting**. More than 30 researchers met in Vienna to share their ideas about →**Complexity: Where do we go from here?**
The two-day meeting started with a public conference that highlighted what the Hub's (External) Faculty thinks are the most pressing or interesting questions for a future understanding of complexity and Big Data. You can find the 31 short presentations on our →*YouTube Channel*. The first tracks are online; over the summer we are going to publish them all. Day Two was dedicated to formulating the trend-setting next steps to future complexity science.

Another great workshop took place in the first week of June. External Faculty member **Frank Schweitzer** from ETH Zurich had been invited for a three-day thinking session about →**Improving resilience in complex systems**. The first afternoon was co-organized as a colloquium with TU Wien that outlined the subject in three lectures: Frank Schweitzer discussed how measures of macroscopic quantities can be used to calibrate and validate an agent-based model of dynamic social organization. **Odirilwe Selomane** from the Stockholm Resilience Centre gave a broad introduction to social-ecological systems, the current understanding of resilience in such systems, their associated dynamics and the applicability for a sustainable development. And CSH president **Stefan Thurner** gave the final talk with an introduction to a very specific tax: the systemic risk tax he and his team have mathematically proven to be superior to other banking regulations for eliminating the collapse risk from financial systems.
On the following two days, the concept of resilience was discussed from different perspectives: How should resilience be quantified? Is there a difference between robustness, stability and resilience? What kinds of data are needed to measure resilience of real world systems? And can we control systems in a way that their resilience is maintained? Frank's aim is to summarize the discussions in a book that represents the state of the art of the subject.
The slides of all presentations shown at this meeting can be found on the respective →event page.

Art at the Hub

A day of scientific inspiration at the CSH External Faculty Meeting was completed with artistic inspiration: Within the →Art at the Hub program we featured the *Word Bodies* (Wortkörper) of the Viennese writer, journalist and artist Johann Berger. His beautiful sculptures and wall panels are derived from characters of ancient Greek and Hebrew script. The "Word Bodies" result from a discourse with Western intellectual history while the technology the artist uses–3D printing, CPI and laser cutting–is deeply rooted in the present. The exhibition is open to visitors until the end of September.

One of Johann Berger's *Word Bodies*.
© Lion Koller

Q+A

Q What are the necessary ingredients for *truly* excellent science?

In April, Brian Arthur, one of the first scientists – and masterminds – at the Santa Fe Institute, paid a visit to the Hub. Between his sessions with intense scientific discussions he was ready to pinch off an hour for a little chat. One of the questions raised was about how to develop excellence in science. Here are some of Brian's quotes, put in a meaningful row.

External Faculty member Brian Arthur visiting the Hub in (much cooler) April 2018. © Verena Ahne

It is hard to investigate new ideas in universities because [they use to work with] fixed theories, fixed orthodoxies – they have fixed ideas how to do things. When you are up to do something out of tradition, you can get quite good science. But you never get great science.

If you want to do interdisciplinary science – which complexity is: It is a different way of looking at things! – you need an atmosphere where people aren't reinforced into all the assumptions of different disciplines. You need a lot of freedom, as opposed to officials telling people what they need to research or people insisting on performance and indices ... Key performance indices are the opposite of doing science! They maybe work for standard science, but they don't work very well if you want to push boundaries. The really great science, which I think goes back to places like Göttingen with quantum theory, wouldn't have been funded by bureaucrats.

The impression I have is that in Europe you have a tradition of insisting on all these indicators, like publications or citation numbers. And I notice that those places where everybody emphasizes KPIs are not at the forefront. In science you want to do creative work, and you can't do that if your publications are measured. Excellence is not measurable, that's something different.

For all institutions that had been extraordinarily successful in America and elsewhere, like the RAND Corporation, that invented a lot of things, including the architecture of the Internet; Bell Labs in the Fifties, that invented the transistor; another one the Cavendish Laboratory in Cambridge with discovering the DNA, for instance, the magic formula is to have excellent people.

If you are up to invent something [entirely new], you have to get people that are absolutely first rate and get them to choose first rate people. [That's not easy because] top level science people are into reputation. Santa Fe, for instance, was totally unknown in its early days. But if you get a phone call from some Nobel Prize winners, as it happened to me, of course you go. First rate, influential people legitimized the place. And you attract further first rate people.

[Once you've got them there] make sure they interact a lot. Be confident that they will do something important. Protect them and see that they are well-funded (it helps if some well-connected people are convinced about the idea and help with the funding ...). And most importantly: Give them a lot of freedom to do what they want, with the task of actually being daring–and you are off and running! Probably seven cases out of ten will not produce that much. But quite a few times you will get something spectacular.

A Get a bunch of absolutely top-notch scientists and give them the freedom to research whatever they think to be important.

The Complexity Science Hub Vienna in the baroque Palais Strozzi. © Verena Ahne

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PUBLICATIONS

This is only a small selection of the dozens of publications affiliated to the Hub. Many more can be found at →*www.csh.ac.at/publications*

M. Sadilek, P. Klimek, S. Thurner
→*Asocial balance—how your friends determine your enemies: understanding the co-evolution of friendship and enmity interactions in a virtual world*, Journal of Computational Social Science 1 (2018) 227–239

D. Bagchi, C. Tsallis
→*Fermi–Pasta–Ulam–Tsingou problems: Passage from Boltzmann to q-statistics*, Physica A, Vol. 491 (2018) 869–873

P. Jizba, J. Korbel, et al.
→*Transitions between superstatistical regimes: Validity, breakdown and applications*, Physica A: Statistical Mechanics and its Applications, Vol 493 (2018) 29–46

E. Kušen, M. Strembeck
→*Why so Emotional? An Analysis of Emotional Bot-generated Content on Twitter*, Proc. of the 3rd International Conference on Complexity, Future Information Systems and Risk (COMPLEXIS), Funchal, Madeira, Portugal (2018) 13–22

J.-P. Aguilar, J. Korbel
→*Option Pricing Models Driven by the Space-Time Fractional Diffusion: Series Representation and Applications*, Fractal Fract 2(1), 15 (2018)

M. Szell
→*Crowdsourced Quantification and Visualization of Urban Mobility Space Inequality*, Urban Planning Vol 3, No 1 (2018) 1–20

D. Garcia, Y. Mitike Kassa, A. Cuevas, M. Cebrian, E. Moro, I. Rahwan, R. Cuevas
→*Analyzing gender inequality through large-scale Facebook advertising data*, PNAS June 19 (2018) 201717781

L. Liu, Y. Wang, R. Sinatra, C. Giles, C. Song, D. Wang
→ *Hot streaks in artistic, cultural, and scientific careers*, Nature 559, 151–152 (2018)

UPCOMING

Our summer will be rather quiet when it comes to larger events. But in September we are starting the new scientific year with several exciting events.

CSH Workshop
→***Machine Behavior***
September 6–7, 2018
With the rise of so-called artificial intelligence, a new discipline emerges: the scientific study of behavior exhibited by "intelligent" machines. The field, called Machine Behavior, studies self-learning software and hardware agents not as products of engineering, but as actors that should be empirically analyzed to reveal their behavioral patterns.
The workshop, organized by CSH's David Garcia, seeks to contribute to the foundation of the young discipline. David brings together an interdisciplinary set of pioneers in the field to set the research agenda for the following years. The focus of the workshop will be on how to tackle the inherent complexity of expert systems, intractable software, and multi-agent systems in which software bots coexist and interact with humans.

CSH-ETH Workshop
→***"First City Olympics"***
September 11, 2018
Cities and social communities can be important agents of global change. The workshop aims to involve cities and relevant organizations into the idea of "City Olympics" and to figure out ways to organize such games on a large scale. The plan is that cities first compete for the best environmentally-friendly, energy-efficient, resource-saving and crisis-proof solutions. In the cooperative phase after the Olympics, they should exchange and support each other with the best ideas, technologies and urban governance concepts. "A participatory approach is more promising to reach the United Nation's Sustainability Goals," says Dirk Helbing, one of the organizers. If the resulting innovations were under the Creative Commons license and open source, they could easily be further developed by everyone, leading to new businesses and a fast and widespread adoption of the best solutions.

CSH Workshop
→***"The Ginkgo Meeting"***
September 17, 2018
"From arts to cosmology, from music to complexity" – with this rather unusual combination we start an experiment. A group of scientists and artists meet at the Hub for an interdisciplinary and transdisciplinary exchange. The source of inspiration, freely picked, is the Gingko biloba tree.
"The ambition of the singular Ginkgo Meeting is to investigate what true understanding is," says one of the organizers, CSH External Faculty member Henrik Jensen. "We are bringing all these curious, talented and creative individuals together to explore what happens when a spectrum of minds is focused on a single unbounded part of reality."
We all are curious about the possible findings!