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References

Aktuell

Cho 2019

Adrian Cho, *Codemakers find algorithms immune to quantum hacks.* science **365** (2019), 730–731.

NIST will select cryptographic standards for the internet that could blunt future hacks by a quantum computer.

Crowther 2019

T. W. Crowther, J. van den Hoogen, J. Wan, M. A. Mayes, A. D. Keiser, L. Mo, C. Averill & D. S. Maynard, *The global soil community and its influence on biogeochemistry.* science **365** (2019), 772.

Soil organisms represent the most biologically diverse community on land and govern the turnover of the largest organic matter pool in the terrestrial biosphere. The highly complex nature of these communities at local scales has traditionally obscured efforts to identify unifying patterns in global soil biodiversity and biogeochemistry. As a result, environmental covariates have generally been used as a proxy to represent the variation in soil community activity in global biogeochemical models. Yet over the past decade, broad-scale studies have begun to see past this local heterogeneity to identify unifying patterns in the biomass, diversity, and composition of certain soil groups across the globe. These unifying patterns provide new insights into the fundamental distribution and dynamics of organic matter on land.

Gollwitzer 2019

Anton Gollwitzer, Cameron Martel, James C. McPartland & John A. Bargh, *Autism spectrum traits predict higher social psychological skill.* PNAS **116** (2019), 19245–19247.

Social-cognitive skills can take different forms, from accurately predicting individuals' intentions, emotions, and thoughts (person perception or folk psychology) to accurately predicting social phenomena more generally. Past research has linked autism spectrum (AS) traits to person perception deficits in the general population. We tested whether AS traits also predict poor accuracy in terms of predicting generalized social phenomena, assessed via participants' accuracy at predicting social psychological phenomena (e.g., social loafing, social projection, group think). We found the opposite. In a sample of ≈6,500 participants in 104 countries, AS traits predicted slightly higher social psychological skill. A second study with 400 participants suggested that heightened systemizing underlies this relationship. Our results indicate that AS traits relate positively to a form of social cognitive skill—predicting social psychological phenomena—and highlight the importance of distinguishing between divergent types of social cognition.

Keywords: social psychological skill | autism | autism traits | person perception | social cognition

Gulick 2019

Sean P. S. Gulick, Timothy J. Bralower & Joanna V. Morgan et al., *The first day of the Cenozoic.* PNAS **116** (2019), 19342–19351.

pnas116-19342-Supplement.pdf

Highly expanded Cretaceous–Paleogene (K-Pg) boundary section from the Chicxulub peak ring, recovered by International Ocean Discovery Program (IODP)–International Continental Scientific Drilling Program (ICDP) Expedition 364, provides an unprecedented window into the immediate aftermath of the impact. Site M0077 includes ≈130 m of impact melt rock and suevite deposited the first day of the Cenozoic covered by <1 m of micrite-rich carbonate deposited over subsequent weeks to years. We present an interpreted series of events based on analyses of these drill cores. Within minutes of the impact, centrally uplifted basement rock collapsed outward to forma peak ring capped in melt rock. Within tens of minutes, the peak ring was covered in ≈40 m of brecciated impact melt rock and coarsegrained suevite, including clasts possibly generated by melt–water interactions during ocean resurge. Within an hour, resurge crested the peak ring, depositing a 10-m-thick layer of suevite with increased particle roundness and sorting. Within hours, the full resurge deposit formed through settling and seiches, resulting in an 80-m-thick fining-upward, sorted suevite in the flooded crater. Within a day, the reflected rim-wave tsunami reached the crater, depositing a cross-bedded sand-to-fine gravel layer enriched in polycyclic aromatic hydrocarbons overlain by charcoal fragments. Generation of a deep crater open to the ocean allowed rapid flooding and sediment accumulation rates among the highest known in the geologic record. The high-resolution section provides insight into the impact environmental effects, including charcoal as evidence for impactinduced wildfires and a paucity of sulfur-rich evaporites from the target supporting rapid global cooling and darkness as extinction mechanisms.

Keywords: Chicxulub impact crater | suevite | Cretaceous–Paleogene | peak ring | tsunami

Sean P. S. Gulick, Timothy J. Bralower, Jens Ormö, Brendon Hall, Kliti Grice, Bettina Schaefer, Shelby Lyons, Katherine H. Freeman, Joanna V. Morgan, Natalia Artemieva, Pim Kaskes, Sietze J. de Graaff, Michael T. Whalen, Gareth S. Collins, Sonia M. Tikoo, Christina Verhagen, Gail L. Christeson, Philippe Claeys, Marco J. L. Coolen, Steven Goderis, Kazuhisa Goto, Richard A. F. Grieve, Naoma McCall, Gordon R. Osinski, Auriol S. P. Rae, Ulrich Riller, Jan Smit, Vivi Vajda, Axel Wittmann & the Expedition Scientists

Significance: Chicxulub impact crater cores from the peak ring include ≈130 m of impact melt rock and breccia deposited on the first day of the Cenozoic. Within minutes of the impact, fluidized basement rocks formed a ring of hills, which were rapidly covered by ≈40 m of impact melt and breccia. Within an hour, ocean waters flooded the deep crater through a northeast embayment, depositing another 90 m of breccia. Within a day, a tsunami deposited material from distant shorelines, including charcoal. Charcoal and absence of sulfur-rich target rocks support the importance of impact-generated fires and release of sulfate aerosols for global cooling and darkness postimpact.

His 2019

Mathilde His, *Stand out as a speaker*. science **365** (2019), 834.

I had been rehearsing my speech for days, but I was still stressed out. I was in the first year of my Ph.D., and my previous public speaking experiences had not exactly been successful. The first one, a presentation to a jury of experts for doctoral funding, had ended in a rush because it was too long; I didn't get the funding. During the second one—the defense of my master's project in front of familiar, benevolent professors—I had been unable to control my shaking voice, which gave the impression that I was about to burst into tears. Now, I was a few hours away from giving my first oral presentation at a conference, practicing the

relaxation exercises I had learned for the occasion and hoping I could get through this one without incident.

Jamieson 2019

Kathleen Hall Jamieson, Marcia McNutt, Veronique Kiermer & Richard Sever, *Signaling the trustworthiness of science*. PNAS **116** (2019), 19231–19236.

pnas116-19231-Supplement1.pdf, pnas116-19231-Supplement2.xlsx

Trust in science increases when scientists and the outlets certifying their work honor science's norms. Scientists often fail to signal to other scientists and, perhaps more importantly, the public that these norms are being upheld. They could do so as they generate, certify, and react to each other's findings: for example, by promoting the use and value of evidence, transparent reporting, self-correction, replication, a culture of critique, and controls for bias. A number of approaches for authors and journals would lead to more effective signals of trustworthiness at the article level. These include article badging, checklists, a more extensive withdrawal ontology, identity verification, better forward linking, and greater transparency.

Keywords: scientific integrity | transparency | signaling trustworthiness

Muller-Parker 2019

Gisèle Muller-Parker, *The rewards of government work*. science **365** (2019), 1054.

The phone rang in my university office. "I'm pleased to tell you that we're funding your grant," the program officer at the U.S. National Science Foundation (NSF) told me. I was elated. I'd spent years trying to win support for my project on sea anemones—and now I could actually do the work. But hours later, I received another call—also from NSF, responding to an application I had filed 4 months earlier. "We'd like to offer you the job as program director," said the caller. The choice before me was stark: I could continue on my academic path, or take a leap into a very different career.

Penilla 2019

E. H. Penilla, G. Aguilar & J. E. Garay et al., *Ultrafast laser welding of ceramics*. science **365** (2019), 803–808.

s365-0803-Supplement.pdf

Welding of ceramics is a key missing component in modern manufacturing. Current Methods cannot join ceramics in proximity to temperature-sensitive materials like polymers and electronic components. We introduce an ultrafast pulsed laser welding approach that relies on focusing light on interfaces to ensure an optical interaction volume in ceramics to stimulate nonlinear absorption processes, causing localized melting rather than ablation. The key is the interplay between linear and nonlinear optical properties and laser energy–material coupling. The welded ceramic assemblies hold high vacuum and have shear strengths comparable to metal-to-ceramic diffusion bonds. Laser welding can make ceramics integral components in devices for harsh environments as well as in optoelectronic and/or electronic packages needing visible-radio frequency transparency.

E. H. Penilla, L. F. Devia-Cruz, A. T. Wieg, P. Martinez-Torres, N. Cuando-Espitia, P. Sellappan, Y. Kodera, G. Aguilar & J. E. Garay

Pennisi 2019

Elizabeth Pennisi„ *Forest giants are the trees most at risk*. science **365** (2019), 962–963.

Lightning, drought, and invasive pests tend to slay the largest trees.

At Science's request, Fei used that study's data to calculate the death rate for different sizes of hemlock, ash, and birch trees, with and without infestation. The largest trees suffered the most damage, which Fei called a "surprise." The biggest ash trees were five times more likely to die when infested by the emerald ash borer, whereas mortality in smaller trees increased only threefold, for example. "In general, larger diameter trees are more likely to die with pest invasion," Fei says. He suspects that, like elderly people, older trees are generally not as robust and are less able to recover from stresses such as invasive insects and pathogens.

"We must protect large old trees much better than we have done previously," Lindenmayer says. Creating a buffer of vegetation around them can help. And oldgrowth forests, which harbor the biggest trees, should be protected from fire or logging, he says. Besides being the most vulnerable, after all, the biggest trees are the slowest to regrow. "Many large old trees are really irreplaceable," Lindenmayer says.

Peters 2019

Ellen Peters, Mary Kate Tompkins, Melissa A. Z. Knoll, Stacy P. Ardoin, Brittany Shoots-Reinhard & Alexa Simon Meara, *Despite high objective numeracy, lower numeric confidence relates to worse financial and medical outcomes*. PNAS **116** (2019), 19386–19391.

pnas116-19386-Supplement.pdf

People often laugh about being "no good at math." Unrecognized, however, is that about one-third of American adults are likely too innumerate to operate effectively in financial and health environments. Two numeric competencies conceivably matter—objective numeracy (ability to "run the numbers" correctly; like literacy but with numbers) and numeric self-efficacy (confidence that provides engagement and persistence in numeric tasks). We reasoned, however, that attaining objective numeracy's benefits should depend on numeric confidence. Specifically, among the more objectively numerate, having more numeric confidence (vs. less) should lead to better outcomes because they persist in numeric tasks and have the skills to support numeric success. Among the less objectively numerate, however, having more (vs. less) numeric confidence should hurt outcomes, as they also persist, but make unrecognized mistakes. Two studies were designed to test the generalizability of this hypothesized interaction. We report secondary analysis of financial outcomes in a diverse US dataset and primary analysis of disease activity among systemic lupus erythematosus patients. In both domains, best outcomes appeared to require numeric calculation skills and the persistence of numeric confidence. "Mismatched" individuals (high ability/low confidence or low ability/high confidence) experienced the worst outcomes. For example, among the most numerate patients, only 7 % of the more numerically confident had predicted disease activity indicative of needing further treatment compared with 31 % of high-numeracy/low-confidence patients and 44 % of low-numeracy/high-confidence patients. Our work underscores that having 1 of these competencies (objective numeracy or numeric selfefficacy) does not guarantee superior outcomes.

Keywords: objective numeracy | numeric confidence | numeric self-efficacy | decision making | financial and health outcomes

Significance: Greater objective ability is thought to lead to more confidence and success across domains. We investigated instead whether objective numeracy and numeric confidence might "mismatch" sometimes and, critically, interact in predicting financial and medical outcomes. The results of 2 studies (secondary analyses of a diverse internet panel and primary analysis of patients with systemic lupus erythematosus) revealed that being more objectively numerate benefits those who

are more numerically confident, but not the less numerically confident. Enjoying good outcomes in finances and health appears to require the persistence of numeric confidence and also the human capital of objective numeracy. The patterns further suggest that improving 1 numerical competency without considering the other could cause harm.

Rodríguez-Cruz 2019

Luis Alexis Rodríguez-Cruz, *Between two worlds, As students and scientists, we cannot alienate ourselves from the issues that matter to us – We must be engaged.* science **365** (2019), 946.

I sat alone in my room, glued to my computer screen, watching events unfold 3000 kilometers away. Back home in Puerto Rico in July, thousands were marching to Old San Juan, demanding that Governor Ricardo Rosselló resign, and I was proud of them. I, however, was in Vermont, pursuing my Ph.D. I had left Puerto Rico because of the academic opportunities available elsewhere—a trade-off many scientists make as we pursue our training and careers. But I still feel deeply connected to my home. I stayed up late following what was happening and talking with friends who were marching, including one who suffered violence at the hands of the police. I was furious at myself for not being there.

Wade 2019

Lizzie Wade, *In search of Sac Balam.* science **365** (2019), 966–970.

The Lacandon Maya resisted Spanish conquest for nearly 200 years. This summer, archaeologists went looking for their capital.

Amerika

Davis 2019

Loren G. Davis, David B. Madsen, Masami Izuho, Fumie Iizuka & Ian Buvit et al., *Late Upper Paleolithic occupation at Cooper's Ferry, Idaho, USA, ≈16,000 years ago.* science **365** (2019), 891–897.

s365-0891-Supplement.pdf

Radiocarbon dating of the earliest occupational phases at the Cooper's Ferry site in western Idaho indicates that people repeatedly occupied the Columbia River basin, starting between 16,560 and 15,280 calibrated years before the present (cal yr B.P.). Artifacts from these early occupations indicate the use of unfluted stemmed projectile point technologies before the appearance of the Clovis Paleoindian tradition and support early cultural connections with northeastern Asian Upper Paleolithic archaeological traditions. The Cooper's Ferry site was initially occupied during a time that predates the opening of an ice-free corridor (≤14,800 cal yr B.P.), which supports the hypothesis that initial human migration into the Americas occurred via a Pacific coastal route.

Loren G. Davis, David B. Madsen, Lorena Becerra-Valdivia, Thomas Higham, David A. Sisson, Sarah M. Skinner, Daniel Stueber, Alexander J. Nyers, Amanda Keen-Zebert, Christina Neudorf, Melissa Cheyney, Masami Izuho, Fumie Iizuka, Samuel R. Burns, Clinton W. Epps, Samuel C. Willis & Ian Buvit

Wade 2019

Lizzie Wade, *Ancient site in Idaho implies first Americans came by sea, 16,000-year-old occupation predates possible land route.* science **365** (2019), 848–849.

Archaeologists have questioned the signs of occupation at some putative pre-Clovis sites, but the stone tools and dating at Cooper's Ferry pass the test with flying colors, says David Meltzer, an archaeologist at Southern Methodist University in Dallas, Texas. "It's pre-Clovis. I'm convinced."

Anthropologie

Callaway 2019

Ewen Callaway, *Denisovan portrait drawn from DNA*. nature **573** (2019), 475–476.

Reconstruction based on epigenetics reveals broad, Neanderthal-like facial features.

Carmel and Gokhman's team first tested whether it could successfully predict the anatomy of Neanderthals, which is known from hundreds of fossils. The team found 33 Neanderthal traits that could potentially be predicted from methylation patterns. The Results accurately predicted 29 of those traits, for instance that the species had broader faces and flatter heads than modern humans.

The researchers then turned the technique on Denisovans. They predicted that these hominins shared many traits with Neanderthals, such as their low foreheads and wide rib cages, but identified some differences, including wider jaws and skulls. Although it is impossible to know how accurate their picture is, some of the predictions are supported by evidence from Denisovan remains.

Culotta 2019

Elizabeth Culotta, *Probing an Evolutionary Riddle*. science **365** (2019), 748–749.

A startling evolutionary hypothesis considers why humans harm themselves—and how they've kept themselves safe for millennia.

Narasimhan 2019

Vagheesh M. Narasimhan1, Nick Patterson & David Reich et al., *The formation of human populations in South and Central Asia*. science **365** (2019), 999.

s365-0999-Supplement1.pdf, s365-0999-Supplement2.xlsx

By sequencing 523 ancient humans, we show that the primary source of ancestry in modern South Asians is a prehistoric genetic gradient between people related to early hunter-gatherers of Iran and Southeast Asia. After the Indus Valley Civilization's decline, its people mixed with individuals in the southeast to form one of the two main ancestral populations of South Asia, whose direct descendants live in southern India. Simultaneously, they mixed with descendants of Steppe pastoralists who, starting around 4000 years ago, spread via Central Asia to form the other main ancestral population. The Steppe ancestry in South Asia has the same profile as that in Bronze Age Eastern Europe, tracking a movement of people that affected both regions and that likely spread the distinctive features shared between Indo-Iranian and Balto-Slavic languages.

Vagheesh M. Narasimhan1, Nick Patterson,3, Priya Moorjani, Nadin Rohland, Rebecca Bernardos, Swapan Mallick, Iosif Lazaridis, Nathan Nakatsuka, Iñigo Olalde, Mark Lipson, Alexander M. Kim, Luca M. Olivieri, Alfredo Coppa, Massimo Vidale, James Mallory, Vyacheslav Moiseyev, Egor Kitov, Janet Monge, Nicole Adamski, Neel Alex, Nasreen Broomandkhoshbacht, Francesca Candilio, Kimberly Callan, Olivia Cheronet, Brendan J. Culleton, Matthew Ferry, Daniel

Fernandes, Suzanne Freilich, Beatriz Gamarra, Daniel Gaudio, Mateja Hajdinjak, Éadaoin Harney, Thomas K. Harper, Denise Keating, Ann Marie Lawson, Matthew Mah, Kirsten Mandl, Megan Michel, Mario Novak, Jonas Oppenheimer, Niraj Rai, Kendra Sirak, Viviane Slon, Kristin Stewardson, Fatma Zalzala, Zhao Zhang, Gaziz Akhatov, Anatoly N. Bagashev, Alessandra Bagnera, Bauryzhan Baitanayev, Julio Bendezu-Sarmiento, Arman A. Bissembaev, Gian Luca Bonora, Temirlan T. Chargynov, Tatiana Chikisheva, Petr K. Dashkovskiy, Anatoly Derevianko, Miroslav Dobeš, Katerina Douka, Nadezhda Dubova, Meiram N. Duisengali, Dmitry Enshin, Andrey Epimakhov, Alexey V. Fribus, Dorian Fuller, Alexander Goryachev, Andrey Gromov, Sergey P. Grushin, Bryan Hanks, Margaret Judd, Erlan Kazizov, Aleksander Khokhlov, Aleksander P. Krygin, Elena Kupriyanova, Pavel Kuznetsov, Donata Luiselli, Farhod Maksudov, Aslan M. Mamedov, Talgat B. Mamirov, Christopher Meiklejohn, Deborah C. Merrett, Roberto Micheli, Oleg Mochalov, Samariddin Mustafokulov, Ayushi Nayak, Davide Pettener, Richard Potts, Dmitry Razhev, Marina Rykun, Stefania Sarno, Tatyana M. Savenkova, Kulyan Sikhymbaeva, Sergey M. Slepchenko, Oroz A. Soltobaev, Nadezhda Stepanova, Svetlana Svyatko, Kubatbek Tabaldiev, Maria Teschler-Nicola, Alexey A. Tishkin, Vitaly V. Tkachev, Sergey Vasilyev, Petr Velemínský, Dmitriy Voyakin, Antonina Yermolayeva, Muhammad Zahir, Valery S. Zubkov, Alisa Zubova, Vasant S. Shinde, Carles Lalueza-Fox, Matthias Meyer, David Anthony, Nicole Boivin, Kumarasamy Thangaraj, Douglas J. Kennett, Michael Frachetti, Ron Pinhasi & David Reich

Price 2019

Michael Price, *Stunning skull shakes human family tree, Researchers reveal the 4-million-year-old face of the most ancient australopithecine.* science **365** (2019), 850.

Schaefer 2019

Nathan K. Schaefer & Beth Shapiro, *New middle chapter in the story of human evolution.* science **365** (2019), 981–982.

Analyzing genomic data from ancient humans illuminates South Asian ancestry.

Bibel

Faust 2018

Avraham Faust, *Social Stratification in the Iron Age Levant.* In: Jonathan S. Greet, John W. Hilber & John H. Walton (Hrsg.), *Behind the Scenes of the Old Testament, Cultural, Social, and Historical Contexts.* (Grand Rapids 2018), 482–491.

This seems to indicate that the common interpretation of the prophets' criticism probably is correct (see also Houston 2004). Still, we have also learned that stratification did not exist in all the settlements, and that the reality was different in the rural sector. The prophets condemned what they saw in front of them. There were indeed social injustices, but these were far more prevalent in the cities. In the villages the situation was different. This picture is supported by B, Uffenheimer's (1968) analysis of the prophecy of Jeremiah. According to Uffenheimer, while Jeremiah resided at Anathoth, he did not mention social problems in his prophecies at all. Only when he moved to Jerusalem did such issues begin to appear in his prophecies (e.g., Jer. 5:27; 22:3). If this observation is correct, the change shows that, at least in seventh-century Judah, these problems existed mainly in the cities

and not in the countryside, and we may extend this conclusion to the reality of the late Iron Age in general.

Faust 2018

Avraham Faust & Yair Sapir, *The "Governor's Residency" at Tel 'Eton, the United Monarchy, and the Impact of the Old-House Effect on Large-Scale Archaeological Reconstructions*. Radiocarbon **60** (2018), 801–820.

The "governor's residency" at Tel 'Eton was destroyed in the late 8th century BCE in an Assyrian military campaign. While the numerous finds enable a detailed reconstruction of life on the eve of the destruction, this elite house was cleaned continuously, and since no floor raisings were identified, little was known of the building's period of use. Radiocarbon (14C) samples taken from within a foundation deposit and from the floor make-up, however, indicate that the earliest phase of the residency was built in the late 11th–10th century BCE. This has bearings on the date in which social complexity evolved in Judah, on the debate regarding the historicity of the kingdom of David and Solomon, and it also provides the earliest date for the use of ashlar stones in Judah. Finally, the long life of the "governor's residency" exemplifies a little addressed phenomenon—the old-house effect—in which buildings and settlements existed for a few centuries, but only left significant remains from their last phase. The earlier phases are hardly represented in the finds, barely studied, and rarely published. We suggest that the old-house effect influences archaeological interpretations worldwide, and is also responsible for recent attempts to down-date social complexity in Judah.

Keywords: ashlar stones | Israel | Judah | old-house effect | United Monarchy.

Klima

ArchaeoGLOBE Project 2019

ArchaeoGLOBE Project, *Archaeological assessment reveals Earth's early transformation through land use*. science **365** (2019), 897–902.

s365-0897-Supplement.pdf

Environmentally transformative human use of land accelerated with the emergence of agriculture, but the extent, trajectory, and implications of these early changes are not well understood. An empirical global assessment of land use from 10,000 years before the present (yr B.P.) to 1850 CE reveals a planet largely transformed by hunter-gatherers, farmers, and pastoralists by 3000 years ago, considerably earlier than the dates in the land-use reconstructions commonly used by Earth scientists. Synthesis of knowledge contributed by more than 250 archaeologists highlighted gaps in archaeological expertise and data quality, which peaked for 2000 yr B.P. and in traditionally studied and wealthier regions. Archaeological reconstruction of global land-use history illuminates the deep roots of Earth's transformation and challenges the emerging Anthropocene paradigm that large-scale anthropogenic global environmental change is mostly a recent phenomenon.

Escobar 2019

Herton Escobar, *Amazon fires clearly linked to deforestation, scientists say*. science **365** (2019), 853.

Brazilian government deflects blame for rise in fire activity.

The numbers are the highest since 2010, when the Amazon experienced a severe drought triggered by El Niño and a warming of the North Atlantic Ocean. This time, climatic anomalies can't explain the uptick, scientists say.

Deforestation can, at least partly. To clear land for farming, settlers fell trees, remove valuable timber, and then set fire to the remainder. Recent INPE data showed deforestation to be on the rise, although Bolsonaro called the numbers "a lie" and had INPE Director Ricardo Galvão fired (Science, 2 August, p. 419). The 10 municipalities with the highest rate of fire activity are also the ones where the forest disappeared most rapidly this year, according to the Amazon Environmental Research Institute in Belém, Brazil.

Hand 2019

Eric Hand, *World's oldest impact crater dated in Australian outback, The 2.2-billion-year-old Yarrabubba impact came at the end of a planetwide deep freeze.* science **365** (2019), 852–853.

That puts the impact at a turbulent time in Earth's history. Life had existed for more than 1 billion years, but photosynthetic life—cyanobacteria living in shallow waters—was a recent evolutionary invention, one that triggered a sharp rise in atmospheric oxygen about 2.4 billion years ago. Previously, high levels of methane in the atmosphere had generated a greenhouse effect that warmed the planet. But many scientists think the methane was destroyed by chemical reactions with Earth's first ozone, produced when ultraviolet light from the sun struck the oxygen molecules. They suspect loss of methane sent Earth crashing into a set of severe and long-lived ice ages, even at low latitudes. Three or maybe four of these icy episodes took place between 2.45 billion and 2.22 billion years ago, which means Australia might have been covered in ice at the time of the Yarrabubba impact.

Scientists have assumed that volcanic eruptions ended the ice ages, by belching carbon dioxide and warming the planet. But Erickson and his colleagues speculate that Yarrabubba could have helped. They modeled the effect of a 7-kilometer-wide asteroid striking an ice sheet between 2 and 5 kilometers thick. They found the impact could have spread dust thousands of kilometers, darkening ice and enhancing its ability to absorb heat. It also would have sent half a trillion tons of steam into the stratosphere—orders of magnitude more water vapor than in today's stratosphere—where it would have trapped heat.

Roberts 2019

Neil Roberts, *How humans changed the face of Earth.* science **365** (2019), 865–866.

Archaeological evidence shows that anthropogenic changes began earlier and spread faster than previously estimated.

Zeebe 2019

Richard E. Zeebe & Lucas J. Lourens, *Solar System chaos and the Paleocene–Eocene boundary age constrained by geology and astronomy.* science **365** (2019), 926–929.

s365-0926-Supplement.pdf

Astronomical calculations reveal the Solar System's dynamical evolution, including its chaoticity, and represent the backbone of cyclostratigraphy and astrochronology. An absolute, fully calibrated astronomical time scale has hitherto been hampered beyond ≈50 million years before the present (Ma) because orbital calculations disagree before that age. Here, we present geologic data and a new astronomical solution (ZB18a) showing exceptional agreement from ≈58 to 53 Ma. We provide a new absolute astrochronology up to 58 Ma and a new Paleocene–Eocene boundary age (56.01 ± 0.05 Ma). We show that the Paleocene–Eocene Thermal Maximum (PETM) onset occurred near a 405-thousandyear (kyr) eccentricity maximum, suggesting an orbital trigger. We also provide an independent

PETM duration (170 ± 30 kyr) from onset to recovery inflection. Our astronomical solution requires a chaotic resonance transition at ≈50 Ma in the Solar System's fundamental frequencies.

Mathematik

Prather 2019

Michael J. Prather & Juno C. Hsu, *A round Earth for climate models.* PNAS **116** (2019), 19330–19335.

pnas116-19330-Supplement.pdf

Sunlight drives the Earth's weather, climate, chemistry, and biosphere. Recent efforts to improve solar heating codes in climate models focused on more accurate treatment of the absorption spectrum or fractional clouds. A mostly forgotten assumption in climate models is that of a flat Earth atmosphere. Spherical atmospheres intercept 2.5 W • m-2 more sunlight and heat the climate by an additional 1.5 W • m-2 globally. Such a systematic shift, being comparable to the radiative forcing change from preindustrial to present, is likely to produce a discernible climate shift that would alter a model's skill in simulating current climate. Regional heating errors, particularly at high latitudes, are several times larger. Unlike flat atmospheres, constituents in a spherical atmosphere, such as clouds and aerosols, alter the total amount of energy received by the Earth. To calculate the net cooling of aerosols in a spherical framework, one must count the increases in both incident and reflected sunlight, thus reducing the aerosol effect by 10 to 14 % relative to using just the increase in reflected. Simple fixes to the current flat Earth climate models can correct much of this oversight, although some inconsistencies will remain.

Keywords: solar radiation | spherical atmospheres | climate modeling

Significance: Early climate and weather models, constrained by computing resources, made numerical approximations on modeling the real world. One process, the radiative transfer of sunlight through the atmosphere, has always been a costly component. As computational ability expanded, these models added resolution, processes, and numerical methods to reduce errors and become the Earth system models that we use today. While many of the original approximations have since been improved, one—that the Earth's surface and atmosphere are locally flat—remains in current models. Correcting from flat to spherical atmospheres leads to regionally differential solar heating at rates comparable to the climate forcing by greenhouse gases and aerosols. In addition, spherical atmospheres change how we evaluate the aerosol direct radiative forcing.

Mittelpaläolithikum

Duveau 2019

Jérémy Duveau, Gilles Berillon, Christine Verna, Gilles Laisné & Dominique Cliquet, *The composition of a Neandertal social group revealed by the hominin footprints at Le Rozel (Normandy, France).* PNAS **116** (2019), 19409–19414.

pnas116-19409-Supplement.pdf

Footprints represent a unique snapshot of hominin life. They provide information on the size and composition of groups that differs from osteological and archeological remains, whose contemporaneity is difficult to establish. We report here on the discovery of 257 footprints dated to 80,000 y from the Paleolithic site

at Le Rozel (Normandy, France), which represent the largest known Neandertal ichnological assemblage to date. We investigate the size and composition of a trackmaker group from this large set by developing a morphometric method based on experimental footprints. Our analyses indicate that the footprints were made by a small group comprising different age classes, from early childhood to adult, with a majority of children. The Le Rozel footprints thus provide direct evidence for the size and composition of a Neandertal social group.

Keywords: footprints | Neandertals | Le Rozel | morphometry | group composition

Significance: The limited knowledge we have of the size and composition of Neandertal social groups is usually based on indirect approaches using archeological or osteological data. In contrast, footprints provide more direct information about group size and composition. However, they are scarce in the fossil record, particularly for Neandertals. The discovery of 257 footprints at Le Rozel (Normandy, France) opens up a new approach for studies of the composition of Neandertal groups. By applying a morphometric method to a sample of fossil footprints made during a single brief occupation event, our analysis shows that they represent a small group with a majority of children and thus provides direct evidence of the composition of a Neandertal group.

Politik

Aral 2019

Sinan Aral & Dean Eckles, *Protecting elections from social media manipulation*. science **365** (2019), 858–861.

s365-0858-Supplement.pdf

Rigorous causal analysis could help harden democracy against future attacks.

Thankfully, social media's effects are, in our view, eminently measurable. Here, we advocate a research agenda for measuring social media manipulation of elections, highlight underutilized approaches to rigorous causal inference, and discuss political, legal, and ethical implications of undertaking such analysis. Consideration of this research agenda illuminates the need to overcome important trade-offs for public and corporate policy—for example, between election integrity and privacy.

Effects of nonpaid exposures, estimated without causal inference, have been off by as much as 300 to 700 %. Yet, causal claims about why social media messages spread are routinely made without any discussion of causal inference.

One important challenge is that statistical precision is often inadequate to answer many questions about effects on voter behavior. [...] The lack of statistical precision in those studies arose in part because only about a tenth of users were uniquely matched to voter records, which, as we note, could be improved upon.

We should recognize that well-intentioned privacy regulations, though important, may also impede assessments like the one that we propose. Similarly, proposed legislation in the United States (the DETOUR Act) could make many routine randomized experiments by these firms illegal (Senate Bill 1084), making future retrospective analyses more difficult and, of course, making ongoing efforts by those firms to limit such manipulation less data-driven.

Achieving a scientific understanding of the effects of social media manipulation on elections is an important civic duty. Without it, democracies remain vulnerable. The sooner we begin a public discussion of the trade-offs between privacy, free speech, and democracy that arise from the pursuit of this science, the sooner we can realize a path forward.