

## References

### Aktuell

#### CAROLIN 2019

Stacy A. Carolin et al., *Paleoscience precision in an archeological or historical context, Reply to Jaffe et al.* [PNAS 116 \(2019\), 4757.](#)

Stacy A. Carolin, Richard T. Walker, Christopher C. Day, Vasile Ersek, R. Alastair Sloan, Michael W. Dee, Morteza Talebian & Gideon M. Henderson

We do not seek to make any general point in our paper that aridity causes societal collapse. We appreciate that such sociopolitical changes can have a myriad of causes. Our analysis focuses specifically on the temporal relationship between the onset of an arid period and the coincident transformation of settlements in north Mesopotamia that were possibly in locations vulnerable to climate variability.

#### ENGEMANN 2019

Kristine Engemann et al., *Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood.* [PNAS 116 \(2019\), 5188–5193.](#)

[pnas116-05188-Supplement.pdf](#)

Kristine Engemann, Carsten Bøcker Pedersen, Lars Arge, Constantinos Tsirogianis, Preben Bo Mortensen & Jens-Christian Svenning

Urban residence is associated with a higher risk of some psychiatric disorders, but the underlying drivers remain unknown. There is increasing evidence that the level of exposure to natural environments impacts mental health, but few large-scale epidemiological studies have assessed the general existence and importance of such associations. Here, we investigate the prospective association between green space and mental health in the Danish population. Green space presence was assessed at the individual level using high-resolution satellite data to calculate the normalized difference vegetation index within a 210 x 210 m square around each person's place of residence ( $\approx 1$  million people) from birth to the age of 10. We show that high levels of green space presence during childhood are associated with lower risk of a wide spectrum of psychiatric disorders later in life. Risk for subsequent mental illness for those who lived with the lowest level of green space during childhood was up to 55% higher across various disorders compared with those who lived with the highest level of green space. The association remained even after adjusting for urbanization, socioeconomic factors, parental history of mental illness, and parental age. Stronger association of cumulative green space presence during childhood compared with single-year green space presence suggests that presence throughout childhood is important. Our results show that green space during childhood is associated with better mental health, supporting efforts to better integrate natural environments into urban planning and childhood life.

**Keywords:** geographic information systems | mental health | psychological ecosystem services | remote sensing | urban planning

**Significance:** Growing up in urban environments is associated with risk of developing psychiatric disorders, but the underlying mechanisms are unknown. Green space can provide mental health benefits and possibly lower risk of psychiatric disorders. This nation-wide study covering >900,000 people shows that children who grew up with the lowest levels of green space had up to 55% higher risk of

developing a psychiatric disorder independent from effects of other known risk factors. Stronger association between cumulated green space and risk during childhood constitutes evidence that prolonged presence of green space is important. Our findings affirm that integrating natural environments into urban planning is a promising approach to improve mental health and reduce the rising global burden of psychiatric disorders.

#### JAFFE 2019

Yitzchak Jaffe, Guy Bar-Oz & Ronnie Ellenblum, *Improving integration in societal consequences to climate change*. *PNAS* **116** (2019), 4755–4756.

Thus, the purported indistinguishability of correlation between the onset of drought and the quick demise of Akkad, essentially reveals scenarios ranging from 150 y of drought until the Akkadian collapse to one in which collapse takes place 13 y before the drought event.

#### LELIEVELD 2019

Jos Lelieveld, Klaus Klingmüller, Andrea Pozzer, Ulrich Pöschl, Mohammed Fnais, Andreas Daiber & Thomas Münzel, *Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions*. *European Heart Journal* (2019), preprint, 1–7. DOI:10.1093/eurheartj/ehz135.

EuHeartJ2019.03-Lelieveld-Supplement1.pdf, EuHeartJ2019.03-Lelieveld-Supplement2.xlsx

**Aims:** Ambient air pollution is a major health risk, leading to respiratory and cardiovascular mortality. A recent Global Exposure Mortality Model, based on an unmatched number of cohort studies in many countries, provides new hazard ratio functions, calling for re-evaluation of the disease burden. Accordingly, we estimated excess cardiovascular mortality attributed to air pollution in Europe.

**Methods and results:** The new hazard ratio functions have been combined with ambient air pollution exposure data to estimate the impacts in Europe and the 28 countries of the European Union (EU-28). The annual excess mortality rate from ambient air pollution in Europe is 790 000 [95 % confidence interval (95 % CI) 645 000–934 000], and 659 000 (95 % CI 537 000–775 000) in the EU-28. Between 40 % and 80 % are due to cardiovascular events, which dominate health outcomes. The upper limit includes events attributed to other non-communicable diseases, which are currently not specified. These estimates exceed recent analyses, such as the Global Burden of Disease for 2015, by more than a factor of two. We estimate that air pollution reduces the mean life expectancy in Europe by about 2.2 years with an annual, attributable per capita mortality rate in Europe of 133/100 000 per year.

**Conclusion:** We provide new data based on novel hazard ratio functions suggesting that the health impacts attributable to ambient air pollution in Europe are substantially higher than previously assumed, though subject to considerable uncertainty. Our results imply that replacing fossil fuels by clean, renewable energy sources could substantially reduce the loss of life expectancy from air pollution.

**Keywords:** Air pollution | Fine particulate matter | Excess mortality rate | Loss of life expectancy | Cardiovascular risk | Health promotion intervention

#### SAGERS 2019

Jessica Sagers, *Waiting for reimbursement*. *science* **363** (2019), 786.

It has been an exciting and productive conference. As a fifth-year Ph.D. student, I am less nervous when I present my work than I used to be, and I finally feel I fit in as a scholar. But when my abstract was accepted in the fall, I had to consider something completely unrelated to my science: whether I could afford to go. Carefully, I did the math. Registration, fees, air travel, lodging, and food would exceed \$1000. My fellowship comes with \$1200 that I can use for conference travel, among other project-related expenses. On top of that, the conference granted my presentation a \$500 travel award. I should be able to cover the costs—eventually.

## Bibel

### NA'AMAN 2017

Nadav Na'aman, *In Search of the Temples of YHWH of Samaria and YHWH of Teman*. [Journal of Ancient Near Eastern Religions 17 \(2017\), 76–95](#).

The Kuntillet 'Ajrud inscriptions mention blessings by the names of YHWH of Samaria and YHWH of Teman. Like all ancient Near Eastern gods, these two regional gods must have had central temples. This article examines their possible locations and suggests that the combination of the Kuntillet 'Ajrud inscriptions with the eighth-century prophecies of Amos and Hosea holds the key for identifying these. In light of a detailed analysis of Hosea's and Amos' prophecies, it is further suggested that YHWH of Samaria was the name of the major God of the Kingdom of Israel and his main temple was located at Bethel, and that YHWH of Teman was the name of the God of the southern desert regions and his temple was located at Beer-sheba. Israelite traders who traveled southward probably visited the latter god's temple, offered him sacrifices, made vows to repay him if they succeed in the expedition, and thus turned him to be their patron god during their travel in the desert region. This suggested identification explains why the Judahite cult place of Beer-sheba appears in Amos' prophecy alongside the Israelite sanctuaries of Bethel, Gilgal, and Dan.

**Keywords:** Kuntillet 'Ajrud | YHWH of Samaria | YHWH of Teman | Bethel | Dan | Beer-sheba

### SERGI 2017

Omer Sergi, *The United Monarchy and the Kingdom of Jeroboam II in the Story of Absalom and Sheba's Revolts (2 Samuel 15–20)*. [Hebrew Bible and Ancient Israel 6 \(2017\), 329–353](#).

The story of Absalom and Sheba's revolts (2 Samuel 15–20) recounts how David's throne was threatened twice when Israel rebelled against him, first under the leadership of his son Absalom, and later under the Benjaminite Sheba. This study discusses the literary unity and the date of the revolts story, first and foremost, by taking into account the historical and geo-political context presupposed by its authors. It is thus demonstrated that the story is based on the geo-political realities of the 8th century b.c.e., and that it recalls the extent and power of the kingdom of Israel under the reign of Jeroboam II. The “great united monarchy” ruled by David as envisioned by the authors of the revolts story actually projects the territories of the kingdoms of Israel and Judah during the reign of Jeroboam II back to the 10th century b.c.e. In light of this conclusion, the study explores the origins of this concept in its literary and historical context.

**Keywords:** succession narrative | King David | united monarchy | Jeroboam II | Israel

## Islam Judentum

FRAISSE 2019

Ottfried Fraisse, *Modern Jewish Scholarship on Islam in Context, Rationality, European Borders, and the Search for Belonging*. In: OTTFRIED FRAISSE (Hrsg.), *Modern Jewish Scholarship on Islam in Context, Rationality, European Borders, and the Search for Belonging*. Studia Judaica 108 (Berlin 2019), 1–29.

The imagery of “Golden Spain” was extensively evoked—although not invented—by those West European Jews in the eighteenth and nineteenth centuries who wanted to gain more political and social recognition in Western societies. They promoted the imagery of “Golden Spain” in order to distance themselves from the traditional Ashkenazic educational system, rabbinic leadership, and mode of worship as then especially prevalent in Eastern Europe. By highlighting the poetic, architectural, and scientific dynamics in Jewish cultures of Muslim Spain the image of a quasi-modern Sephardic Jew was nurtured by enlightened Ashkenazic intellectuals in order to display cultural openness, appreciation for the aesthetic, and acquaintance with philosophical knowledge. The ingenuity of this image of “Golden Spain” was to enable both the assimilation of the Ashkenazim within the borders of (West) European societies and assist in anchoring their rebellion in Jewish soil. However, when historical research at the end of the twentieth century observed that those European Jews of the eighteenth and nineteenth centuries who upheld the imagery of “Golden Spain” were not genuinely interested in the relationship between Jews and Muslims in medieval Spain but in “a usable past,” the modern discourse of “Sephardic supremacy” was rightly labelled a myth. But how do the scholars of Jewish origin who about between 1830 and 1930 researched Islam in quite great number, and in an exceptionally profound and sustainable manner, fit into this research narrative?

FRAISSE 2019

Ottfried Fraisse, *Martin Schreiner’s Unpublished Systematic Philosophy of Religion, Adapting Ignác Goldziher’s Method for Researching Islam*. In: OTTFRIED FRAISSE (Hrsg.), *Modern Jewish Scholarship on Islam in Context, Rationality, European Borders, and the Search for Belonging*. Studia Judaica 108 (Berlin 2019), 245–245.

Schreiner was a supporter of an exclusive notion of systematic truth which seems to have already been outdated in his own days. In chapter 7 (“The Proof of Religious Truth”) he asks: “But is it possible at all to prove the truth of a religion, the objective reality of its ideas and if so, what are the criteria of truth and perfection?” On the other hand, his answer is that “a teaching which is in contradiction with science must simply be given up, since two contradicting notions of truth cannot exist.” On the other, because Schreiner was also convinced that indeed “the whole system of Jewish philosophy of religion,” unlike any other religion, can be reconstructed from a single objective prerequisite, namely the “existence of an unrecognizable world basis,” he could not avoid eventually denying the truth of any other religion except for Judaism and necessarily had to come to the following unequivocal conclusion: “Judaism is the only true religion.” If Schreiner proclaimed that “since the time of the prophets, Judaism has never given up the belief that its teaching will be accepted by all peoples,” his project of a systematic Jewish philosophy of religion seems to be an attempt to anticipate other religions agreeing to accept Judaism as the only true religion.

## Klima

TREAT 2019

Claire C. Treat et al., *Widespread global peatland establishment and persistence over the last 130,000 y.* *PNAS* **116** (2019), 4822–4827.

pnas116-04822-Supplement1.pdf, pnas116-04822-Supplement2.xlsx, pnas116-04822-Supplement3.xlsx

Claire C. Treat, Thomas Kleinen, Nils Broothaerts, April S. Dalton, Rene Dommain, Thomas A. Douglas, Judith Z. Drexler, Sarah A. Finkelstein, Guido Grosse, Geoffrey Hope, Jack Hutchings, Miriam C. Jones, Peter Kuhry, Terri Lacourse, Outi Lahteenoja, Julie Loisel, Bastiaan Notebaert, Richard J. Payne, Dorothy M. Peteet, A. Britta K. Sannel, Jonathan M. Stelling, Jens Strauss, Graeme T. Swindles, Julie Talbot, Charles Tarnocai, Gert Verstraeten, Christopher J. Williams, Zhengyu Xia, Zicheng Yu, Minna Valiranta, Martina Hattestrand, Helena Alexanderson & Victor Brovkin

Glacial-interglacial variations in CO<sub>2</sub> and methane in polar ice cores have been attributed, in part, to changes in global wetland extent, but the wetland distribution before the Last Glacial Maximum (LGM, 21 ka to 18 ka) remains virtually unknown. We present a study of global peatland extent and carbon (C) stocks through the last glacial cycle (130 ka to present) using a newly compiled database of 1,063 detailed stratigraphic records of peat deposits buried by mineral sediments, as well as a global peatland model. Quantitative agreement between modeling and observations shows extensive peat accumulation before the LGM in northern latitudes (>40°N), particularly during warmer periods including the last interglacial (130 ka to 116 ka, MIS 5e) and the interstadial (57 ka to 29 ka, MIS 3). During cooling periods of glacial advance and permafrost formation, the burial of northern peatlands by glaciers and mineral sediments decreased active peatland extent, thickness, and modeled C stocks by 70 to 90% from warmer times. Tropical peatland extent and C stocks show little temporal variation throughout the study period. While the increased burial of northern peats was correlated with cooling periods, the burial of tropical peat was predominately driven by changes in sea level and regional hydrology. Peat burial by mineral sediments represents a mechanism for long-term terrestrial C storage in the Earth system. These results show that northern peatlands accumulate significant C stocks during warmer times, indicating their potential for C sequestration during the warming Anthropocene.

Keywords: peatlands | carbon | methane | carbon burial | Quaternary

Significance: During the Holocene (11,600 y ago to present), northern peatlands accumulated significant C stocks over millennia. However, virtually nothing is known about peatlands that are no longer in the landscape, including ones formed prior to the Holocene: Where were they, when did they form, and why did they disappear? We used records of peatlands buried by mineral sediments for a reconstruction of peat-forming wetlands for the past 130,000 y. Northern peatlands expanded across high latitudes during warm periods and were buried during periods of glacial advance in northern latitudes. Thus, peat accumulation and burial represent a key long-term C storage mechanism in the Earth system.

## Mittelpaläolithikum

HAEUSLER 2019

Martin Haeusler, Erik Trinkaus, Cinzia Fornai, Jonas Müller, Noémie Bonneau, Thomas Boeni & Nakita Frater, *Morphology, pathology, and*

*the vertebral posture of the La Chapelle-aux-Saints Neandertal.* [PNAS 116 \(2019\), 4923–4927.](#)

[pnas116-04923-Supplement.pdf](#)

Although the early postural reconstructions of the Neandertals as incompletely erect were rejected half a century ago, recent studies of Neandertal vertebral remains have inferred a hypolordotic, flat lower back and spinal imbalance for them, including the La Chapelle-aux-Saints 1 skeleton. These studies form part of a persistent trend to view the Neandertals as less “human” than ourselves despite growing evidence for little if any differences in basic functional anatomy and behavioral capabilities. We have therefore reassessed the spinal posture of La Chapelle-aux-Saints 1 using a new pelvic reconstruction to infer lumbar lordosis, interarticulation of lower lumbar (L4-S1) and cervical (C4-T2) vertebrae, and consideration of his widespread age-related osteoarthritis. La Chapelle-aux-Saints 1 exhibits a pelvic incidence (and hence lumbar lordosis) similar to modern humans, articulation of lumbar and cervical vertebrae indicating pronounced lordosis, and Bastrup disease as a product of his advanced age, osteoarthritis, and lordosis. Our findings challenge the view of generally small spinal curvatures in Neandertals. Setting aside the developmentally abnormal Kebara 2 vertebral column, La Chapelle-aux-Saints 1 is joined by other Neandertals with sufficient vertebral remains in providing them with a fully upright (and human) axial posture.

**Keywords:** human evolution | Late Pleistocene Homo | lumbar lordosis | spino-pelvic morphology | paleopathology

**Significance:** Fully upright and balanced posture is one of the hallmarks of humanity, and it has long been seen as present among all members of the genus Homo. However, recent considerations of Neandertal vertebrae have concluded that these late archaic humans, who were both behaviorally and phylogenetically close to ourselves, lacked fully developed spinal curvatures and must therefore have had precarious postures. Reassessment and virtual reconstruction of the La Chapelle-aux-Saints 1 Neandertal skeletal remains provides direct anatomical evidence that he, and by extension other Neandertals, possessed the usual human lower back and neck curvature (lordosis). It is therefore time to move beyond making Neandertals less human and focus on the subtle shifts in Late Pleistocene human biology and behavior.

## JAOUEN 2019

Klervia Jaouen et al., *Exceptionally high  $\delta^{15}\text{N}$  values in collagen single amino acids confirm Neandertals as high-trophic level carnivores.* [PNAS 116 \(2019\), 4928–4933.](#)

[pnas116-04928-Supplement1.pdf](#), [pnas116-04928-Supplement2.xlsx](#)

Klervia Jaouen, Michael P. Richards, Adeline Le Cabec, Frido Welker, William Rendu, Jean-Jacques Hublin, Marie Soressi & Sahra Talamo

Isotope and archeological analyses of Paleolithic food webs have suggested that Neandertal subsistence relied mainly on the consumption of large herbivores. This conclusion was primarily based on elevated nitrogen isotope ratios in Neandertal bone collagen and has been significantly debated. This discussion relies on the observation that similar high nitrogen isotope values could also be the result of the consumption of mammoths, young animals, putrid meat, cooked food, freshwater fish, carnivores, or mushrooms. Recently, compound-specific C and N isotope analyses of bone collagen amino acids have been demonstrated to add significantly more information about trophic levels and aquatic food consumption. We undertook single amino acid C and N isotope analysis on two Neandertals, which were characterized by exceptionally high N isotope ratios in their bulk bone or tooth collagen. We report here both C and N isotope ratios on single amino acids of col-

lagen samples for these two Neandertals and associated fauna. The samples come from two sites dating to the Middle to Upper Paleolithic transition period (Les Cottés and Grotte du Renne, France). Our results reinforce the interpretation of Neandertal dietary adaptations as successful top-level carnivores, even after the arrival of modern humans in Europe. They also demonstrate that high  $\delta^{15}\text{N}$  values of bone collagen can solely be explained by mammal meat consumption, as supported by archeological and zooarcheological evidence, without necessarily invoking explanations including the processing of food (cooking, fermenting), the consumption of mammoths or young mammals, or additional (freshwater fish, mushrooms) dietary protein sources.

**Keywords:** compound-specific isotope analyses | diet | late Neandertals | Paleolithic | stable isotopes

**Significance:** Identifying past hominin diets is a key to understanding adaptation and biological evolution. Bone collagen isotope studies have added much to the discussion of Neandertal subsistence strategies, providing direct measures of diet. Neandertals consistently show very elevated nitrogen isotope values. These values have been seen as the signature of a top-level carnivore diet, but this interpretation was recently challenged by a number of additional theories. We here apply compound-specific isotope analysis of carbon and nitrogen in bone collagen single amino acids of two Neandertals. These Neandertals had the highest nitrogen isotope ratios of bulk collagen measured so far, and our study confirms that these values can be most parsimoniously explained by a carnivorous diet.

## WROTH 2019

Kristen Wroth et al., *Neandertal plant use and pyrotechnology, Phytolith analysis from Roc de Marsal, France*. [Archaeological and Anthropological Sciences \(2019\), preprint, 1–22](#). DOI:10.1007/s12520-019-00793-9.

Kristen Wroth, Dan Cabanes, John M. Marston, Vera Aldeias, Dennis Sandgathe, Alain Turq, Paul Goldberg & Harold L. Dibble

The plant component of Neandertal subsistence and technology is not well documented, partially due to the preservation constraints of macrobotanical components. Phytoliths, however, are preserved even when other plant remains have decayed and so provide evidence for Neandertal plant use and the environmental context of archaeological sites. Phytolith assemblages from Roc de Marsal, a Middle Paleolithic cave site in SW France, provide new insight into the relationship between Neandertals and plant resources. Ninety-seven samples from all archaeological units and 18 control samples are analyzed. Phytoliths from the wood and bark of dicotyledonous plants are the most prevalent, but there is also a significant proportion of grass phytoliths in many samples. Phytolith densities are much greater in earlier layers, which is likely related to the presence of combustion features in those layers. These phytoliths indicate a warmer, wetter climate, whereas phytoliths from upper layers indicate a cooler, drier environment. Phytoliths recovered from combustion features indicate that wood was the primary plant fuel source, while grasses may have been used as surface preparations.

**Keywords:** Phytoliths | France | Middle Paleolithic | Neandertals | Pyrotechnology

## Neolithikum

## SANTANA 2019

Jonathan Santana, Francisco Javier Rodríguez-Santos, María Dolores

Camalich-Massieu, Dimas Martín-Socas & Rosa Fregel, *Aggressive or funerary cannibalism? Skull-cup and human bone manipulation in Cueva de El Toro (Early Neolithic, southern Iberia)*. *American Journal of Physical Anthropology* (2019), preprint, 1–24. DOI:10.1002/ajpa.23805.

AmJPhysAnth2019.03-Santana-Supplement1.pdf, AmJPhysAnth2019.03-Santana-Supplement2.pdf

**Objective:** We analyze the processing sequence involved in the manufacture of a skull-cup and the manipulation of human bones from the Early Neolithic of Cueva de El Toro (Málaga, Spain).

**Materials and methods:** The Early Neolithic material studied includes human remains found in two separate assemblages. Assemblage A consists of one skull-cup, a non-manipulated adult human mandible, and four ceramic vessels. Assemblage B contains manipulated and nonmanipulated human remains that appeared mingled with domestic waste. Using a taphonomic approach, we evaluate the skull-cup processing and the anthropogenic alteration of human bones.

**Results:** The skull-cup was processed by careful paring away of skin, fragmentation of the facial skeleton and base of the skull, and controlled percussion of the edges of the calotte to achieve a regular shape. It was later boiled for some time in a container that caused pot polish in a specific area. The other human bones appeared scattered throughout the living area, mixed with other remains of domestic activity. Some of these bones show cut marks, percussion damage for marrow extraction, and tooth/chewing marks.

**Discussion:** Evidence from Cueva de El Toro suggests that cannibalism was conducted in the domestic sphere, likely following ritualized practices where the skull-cup could have played a part. Interpretation of this evidence suggests two hypotheses: (a) aggressive cannibalism relates to extreme inter-group violence; and (b) funerary cannibalism is a facet of multi-stage burial practices. Similar evidence has been found in other Neolithic sites of this region and suggests that cannibalism and skull-cups were elements widespread in these communities. These practices may be linked to significant transformations associated with the end of the Early Neolithic in southern Iberia.

**Keywords:** Andalusia | funerary practice | human skull-cup | Neolithic | prehistoric cannibalism

## Ostasien

PENNY 2019

Dan Penny, Tegan Hall, Damian Evans & Martin Polkinghorne, *Geoarchaeological evidence from Angkor, Cambodia, reveals a gradual decline rather than a catastrophic 15th-century collapse*. *PNAS* **116** (2019), 4871–4876.

pnas116-04871-Supplement.pdf

Alternative models exist for the movement of large urban populations following the 15th-century CE abandonment of Angkor, Cambodia. One model emphasizes an urban diaspora following the implosion of state control in the capital related, in part, to hydroclimatic variability. An alternative model suggests a more complex picture and a gradual rather than catastrophic demographic movement. No decisive empirical data exist to distinguish between these two competing models. Here we show that the intensity of land use within the economic and administrative core of the city began to decline more than one century before the Ayutthayan invasion



that conventionally marks the end of the Angkor Period. Using paleobotanical and stratigraphic data derived from radiometrically dated sediment cores extracted from the 12th-century walled city of Angkor Thom, we show that indicia for burning, forest disturbance, and soil erosion all decline as early as the first decades of the 14th century CE, and that the moat of Angkor Thom was no longer being maintained by the end of the 14th century. These data indicate a protracted decline in occupation within the economic and administrative core of the city, rather than an abrupt demographic collapse, suggesting the focus of power began to shift to urban centers outside of the capital during the 14th century.

**Keywords:** Angkor | collapse | Cambodia | archaeology

**Significance:** Contrasting models exist to explain the movement of urban populations following the 15th-century demise of Angkor. Here we present geoarchaeological data from the urban core of Angkor that indicate a protracted decline in land use intensity during the 14th century rather than an abrupt demographic collapse. These results argue against traditional explanations for the demise of Angkor, which emphasize the role of interventionist foreign powers in forcing collapse, and imply a more complex and protracted transformation.

## Politik

MOORE 2019

Frances C. Moore, Nick Obradovich, Flavio Lehner & Patrick Baylis, *Rapidly declining remarkability of temperature anomalies may obscure public perception of climate change*. [PNAS 116 \(2019\), 4905–4910](#).

[pnas116-04905-Supplement.pdf](#)

The changing global climate is producing increasingly unusual weather relative to preindustrial conditions. In an absolute sense, these changing conditions constitute direct evidence of anthropogenic climate change. However, human evaluation of weather as either normal or abnormal will also be influenced by a range of factors including expectations, memory limitations, and cognitive biases. Here we show that experience of weather in recent years—rather than longer historical periods—determines the climatic baseline against which current weather is evaluated, potentially obscuring public recognition of anthropogenic climate change. We employ variation in decadal trends in temperature at weekly and county resolution over the continental United States, combined with discussion of the weather drawn from over 2 billion social media posts. These data indicate that the remarkability of particular temperatures changes rapidly with repeated exposure. Using sentiment analysis tools, we provide evidence for a “boiling frog” effect: The declining noteworthiness of historically extreme temperatures is not accompanied by a decline in the negative sentiment that they induce, indicating that social normalization of extreme conditions rather than adaptation is driving these results. Using climate model projections we show that, despite large increases in absolute temperature, anomalies relative to our empirically estimated shifting baseline are small and not clearly distinguishable from zero throughout the 21st century.

**Keywords:** climate change | perception | Twitter | baseline | temperature

**Significance:** Climate change exposes people to conditions that are historically unusual but that will become increasingly common over time. What kind of weather do people think of as normal or unusual under these changing conditions? We use the volume of social media posts about weather to measure the remarkability of different temperatures and show that remarkability changes rapidly with repeated exposure to unusual temperatures. The reference point for normal conditions appears to be based on weather experienced between 2 and 8 y ago. This

rapidly shifting normal baseline means warming noticed by the general public may not be clearly distinguishable from zero over the 21st century, with potential implications for both the acceptance of global warming and public pressure for mitigation policies.