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Response to: Comment on 'A global environmental crisis 42,000 years ago' by Hawks.

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Abstract

Our paper about the impacts of the Laschamps Geomagnetic Excursion 42,000 years ago has provoked considerable scientific and public interest, particularly in the so-called Adams Event associated with the initial transition of the magnetic poles. Although we welcome the opportunity to discuss our new ideas, Hawks' assertions of misrepresentation are especially disappointing given his limited examination of the material.

Main text

Our study (*1*) identifies multiple synchronous environmental and archaeological shifts consistent with a global event around 42,000 years ago (42ka), something not previously possible given the uncertainties in the radiocarbon timescale prior to this work. In addition, recent refinements of the radiocarbon calibration curve will compress the dates of many other events around this time even closer to the Laschamps (*2*). Whilst a common driver behind this set of observations is consistent with our chemistry-climate model predictions of the impacts of a collapsed magnetic field, solar minima, and solar energetic particle events, they remain only temporally associated and further study is required to reveal exact mechanisms. In this regard, Hawks (*3*) provides no evidence that challenges our model, and indeed nearly all his contentions are directly contradicted by the quoted references.

For example, in the thylacine study (*4*) Hawks has confused the date for the mitochondrial genetic bottleneck within the remnant Tasmanian population (3-20ka) with that for thylacine populations across the whole of Australia (ancestral divergence, 42ka; *4: Table 3, Fig 7*). Mitochondrial diversity started accumulating within the Australian-wide population around 42ka, leading us to propose a population bottleneck caused by the Adams Event.

Similarly, we do not claim that Australian megafaunal extinctions only occurred at 42ka and not before, as Hawks suggests, although the Signor-Lipps effect ensures that the last observation of poorly sampled taxa (which include the oldest apparent Australian extinctions) will occur well before the actual extinction. While more detailed dating is required, Australian-wide compilations indicate a concentration of extinction events around 42ka,

contemporaneous with major climatic and vegetation shifts in paleoenvironmental records across Australia (*1*). As expected, regional studies differ slightly on the estimated timing of the final megafaunal extinction phase (*5: Fig 1*), and reflect the amount of accurate dating available, but have been explicitly linked to the Laschamps Excursion at Lake Mungo (*6*). Recent studies, including those referenced by Hawks (*7*) have concluded that climate change around this time was indeed the likely driver of Australian megafaunal extinctions, with humans a key additional stressor compared to previous glacial cycles.

Hawks also missed that our study of Eurasian megafaunal extinctions (*8*) explicitly highlighted a cluster around Greenland Interstadials 7-5 (35-32ka) overlapping the date of Mono Lake (*1*, *5: Fig. 1*) that included bison, mammoth, and woolly rhino (*8: Fig 1*). While Eurasian megafaunal extinctions were broadly distributed through time, very few datasets covered the 42ka period in any detail (*8*), severely limiting the ability to detect any pulse of megafaunal genetic transitions during the Laschamps. The only megafaunal group with large amounts of dating and genetic data around this time, humans, do clearly show marked genetic extinctions (*1*, *5: Fig. 1*).

Our observation that the re-calibrated extinction date for Neanderthals at 41-40.5ka is contemporaneous with the end of the Laschamps Excursion (*1, 2, 5: Fig. 1*) has drawn much attention. As with the Australian megafauna, while we highlighted that the final extinction phase occurred during the Laschamps, we noted this represented the end of a much longer process. For European Neanderthals, we discussed the archaeological evidence for a spatiotemporally staggered replacement process by Anatomically Modern Humans (AMH), and the fact that sterile layers separating the two groups within individual sites have been associated with cold Greenland Stadials 12-10 (*9*). Importantly, our new kauri-based radiocarbon calibration allows us to reveal that both GS-11 and 10 are closely aligned to the transition phases of the geomagnetic reversal, when we expect the weak field strength to produce pronounced cooling effects over the North Atlantic (*1, 5: Fig. 1*).

As we stated, the most comprehensive dating study of the Neanderthal extinction/replacement process (*10*) had indeed identified that the end of the Uluzzian and Neanderthal cultures in Italy were near contemporaneous (*10: Fig 2*), while recent work shows the Uluzzian ended over a millennium before the 39.9ka Campanian Ignimbrite (*11*). Similarly, the Bajondillo Cave study noted that the most reliable radiocarbon dates (from short-lived taxa) dated the Proto-Early Aurignacian at 42.15-41.2ka (*12*), consistent with other sites across Europe (*5: Fig. 1*).

Hawks also disputes the evidence that cave art becomes more intense from 42 ka. However we present the data showing a marked increase in the appearance and/or frequency of figurative cave art globally around 42ka (*1*). As we noted, the increased preservation of art and the synchronous global change in artistic behavior around this time has previously been observed by archaeologists (*13*), along with the altered use of caves and ochre (*1*). Indeed, the puzzling observation that ‘similar cave art traditions appear to arise near-contemporaneously in the extreme west and extreme east of Eurasia’ around this time has been noted (*13*) but the

'cause remains unknown'. We explicitly proposed that previously existent artistic practices were shifted into caves during the Laschamps, enhancing preservation potential and generating an apparent marked change in AMH behavior (*1*). This is entirely consistent with earlier but relatively rare cave wall pigment markings (some potentially by Neanderthals). Hawks similarly neglects to mention that the dating of calcite layers situated above and below cave art has allowed tightly bracketed dating, such as the Mono Lake-aged red circle series in El Castillo, which itself parallels the maximum-age dated Laschamps red circle series (*1*).

In our paper we presented a range of data showing marked global and long term environmental and climate changes around 42ka, which Hawks appears to have misunderstood or missed entirely. We clearly stated that the Laschamps represented the common endpoint of processes such as the Neanderthal and megafaunal extinctions, and marked changes in the occurrence of cave art, and it is a clear misrepresentation to suggest otherwise. Our study proposes a geomagnetic mechanism that can explain these and many other palaeoclimatic and archaeological observations through a common forcing. As a result, while further work will be required, 42 does indeed appear to provide an answer to many current mysteries concerning Life, the role of the Universe (cosmic radiation), and a growing number of other things.

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