Using new radiocarbon 3.0 method to study interaction between Homo sapiens and Neanderthals

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Professor Sahra Talamo, director of the BRAVHO Radiocarbon Laboratory at the University of Bologna and first author of the study. Credit: University of Bologna

It is called radiocarbon 3.0, the newest method in radiocarbon dating, and promises to reveal valuable new insights about key events in the earliest human history, starting with the interaction between Homo sapiens and Neanderthals in Europe. This is shown by the combination of updated radiocarbon pretreatment, the latest AMS instrumental advances, and the application of the Bayesian model coupled with the new IntCal20, including the Kauri floating tree-ring section.

These important findings, published in the journal *PLOS ONE*, are the result of extensive research coordinated by Professor Sahra Talamo, director of the BRAVHO Radiocarbon Laboratory at the University of Bologna. Two international radiocarbon experts from the University of Heidelberg (Germany) and ETH Zurich (Switzerland) collaborated on the research as well as the isotope expert at Simon Fraser University (Canada).

The new publication presents an advanced evaluation and discussion of two earlier, widely recognized publications focused on the earliest Homo sapiens in Europe and their temporal relationship with Neanderthals. The crucial challenge is high temporal resolution chronology, which so far was severely limited by the low number of dates per site, low resolution of the radiocarbon calibration curve, and limited Bayesian modeling.

In this new publication, these central aspects are addressed in a new, fully integrated way: (1) Only dates of samples pretreated in the state-of-the-art methodology are considered, (2) the most recent advances in the

AMS radiocarbon measurement technique are applied, and (3) radiocarbon calibration is now based on a section of high-resolution Glacial tree-ring chronologies in the age range of 44,000 and 41,000 calendar years BP (Before 1950 AD).

The concise amalgamation of these three aspects, called radiocarbon 3.0, leads to a new level of temporal interrelation between Homo sapiens at the site of Bacho Kiro, Bulgaria, and, for the first time, a link between the respective presence of modern humans to climatic events (warm and cold phases) in the Glacial, documented in Greenland ice cores.

"Using radiocarbon 3.0, we were able to reconstruct more accurately the movements of ancient hominids, which occurred at major European archaeological sites, during different climatic phases," says Sahra Talamo, professor at the University of Bologna's Department of Chemistry "Giacomo Ciamician" and first author of the study.

"Thanks to this kind of analysis, it is therefore possible to obtain new valuable information on the evolution of the earliest human settlements and the resilience of hominids in different climatic phases, all of which may have contributed to the global spread of Homo sapiens."

Radiocarbon is the most widely applied dating method in archaeology, especially in studies of human evolution. In recent decades, it has enabled scholars around the world to make important advances in reconstructing the chronology of key events in our history.

However, this method, based on the detection of a radioactive isotope carbon-14 in organic samples, does not always obtain sufficiently precise and accurate dates to reveal important processes of human evolution, e.g., the interaction between Neanderthals and Homo sapiens. The challenge was therefore to expand the capabilities of radiocarbon, increasing its high temporal resolution chronology.

Researchers looking for fossilized trees: tree-ring chronologies are used for Radiocarbon calibration. Credit: University of Bologna

Two new Bayesian models were constructed, using the direct dates of Homo sapiens at Bacho Kiro, and Neanderthal dates of Vindija, Croatia, and Fonds-de-Foret, Belgium. Only the high-precision dates of Bacho Kiro allowed the researchers to assign the presence of Homo sapiens at this site during the cold phase of GS 12.

"In this study, we have shown that the human occupation at Bacho Kiro did not occur at once, but there were three different occupations (one

around 44650 to 44430, one at 44200 to 43420 and one at 43110 to 42700 cal BP) or two different ones (one around 44650 to 44430, one at 44310 to 43710 cal BP), depending on the ^{14}C dates considered and the Bayesian model used," explains Talamo.

At present, both scenarios could be supported because it is not yet known whether the Initial Upper Paleolithic may have lasted longer in Bacho Kiro than in the Levant or may have overlapped temporally with the Protoaurignacian dispersal.

"Moreover, obtaining a small ^{14}C error in a time period around 42,000 years ago is a key point of radiocarbon 3.0," explains Lukas Wacker, at the ETH Zurich and co-author of the paper. "The better this error interval is defined and obtained, the more accurate the final age calibration process will be."

"In this paper, we have demonstrated the potential and advantages, both in terms of temporal and environmental accuracy, of discussing chronologies obtained from ^{14}C ages with the same tight error intervals," says Bernd Kromer at the University of Heidelberg (Germany) and co-author of the paper. "In addition, the extent of the Initial Upper Paleolithic (IUP) is constrained better by the new models, compared to the previous publications."

"Our exercise shows that using radiocarbon 3.0, we are able to accomplish the definitive high resolution of European key archaeological sites during recurrent climate fluctuations, and model the human and faunal species' responses from a diachronic perspective," explains Michael Richards at Simon Fraser University (Canada) and co-author of the paper. "This is the way to promote knowledge exchange between archaeology, palaeoclimatology, geochronology, and geosciences in general, all essential disciplines in the study of the human past."

The study was published in the journal *PLOS ONE* and titled "Back to the future: the advantage of studying key events in human evolution using a new high-resolution radiocarbon method."

More information: Back to the future: the advantage of studying key events in human evolution using a new high resolution radiocarbon method, *PLOS ONE* (2023). DOI: 10.1371/journal.pone.0280598

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