Towards Precise Dating
An 18th-century clergyman's legacy

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For the past decade, English Heritage has used mathematical techniques to interpret radiocarbon dates. This has led to more precise chronologies and has increased the range of questions that can be answered.

In 1763, the Reverend Thomas Bayes' 'Essay Towards Solving a Problem in the Doctrine of Chances,' published posthumously in the *Philosophical Transactions of the Royal Society of London*, introduced Bayes' Theorem (*left*). This mathematical equation allows new data to be interpreted in the light of existing knowledge ('prior beliefs') to derive new insights into a problem ('posterior beliefs').

For more than 200 years, however, Bayes' idea lay dormant, as no solution could be found for his equation. This changed in the late 1980s when advances in computing began to allow solutions using simulation.

Archaeology was quick to identify the potential of this new method, and the first software allowing the routine application of this approach for the interpretation of radiocarbon dates became available in 1993. Since that time, more than 2000 ^{14}C dates have been commissioned by English Heritage, of which about 85 per cent have been included in chronological models combining the absolute chronological information provided by the radiocarbon dates with the relative dating sequence provided by archaeological stratigraphy. This evidence allows some areas of probability to be excluded and more precise dating to be achieved.

During the past decade, this approach has increased the precision of archaeological chronologies provided by radiocarbon dating for English Heritage projects by about 35 per cent (for example, where a simple calibrated date range might span 300 years, the *posterior density estimate* spans only 200 years). The gain in precision, however, is not equally spread over all projects. It is greatest for sites with full archaeological excavation, vertical stratigraphy, and well-preserved bone or other organic material. For such sites, refined chronologies with a resolution of under a century are often now achievable.

$$P(parameters \mid data) = \frac{P(data \mid parameters)}{P(data)} \times P(parameters)$$

Posterior belief = Standardised likelihood x Prior belief

Bayes Theorem.

The benefits

Refined chronologies have two consequences. First, they allow scientific dating to be useful in a wider range of archaeological periods. In particular, radiocarbon dating can now provide sufficient precision to be informative in proto-historic and historic periods where traditional archaeological chronologies are already comparatively refined. For example, useful applications have been undertaken in both the early medieval period and the middle Iron Age.

The second consequence is that the range of chronological questions which can be tackled with these new techniques has been extended. The question is no longer, for example, 'in which half of the fourth millennium was the Stepleton enclosure built?', but 'was it built before or after the main enclosure at Hambledon?', 'for how long was it in use?', and 'how does it relate to the construction and use of other monuments in the landscape?'. In fact, for the first time, we have a realistic chance of answering all these questions in a quantitative manner.

The 18th-century Enlightenment produced the equation, 20th-century computer science enabled the simulation of solutions and 21st-century archaeology will reap the benefit. □