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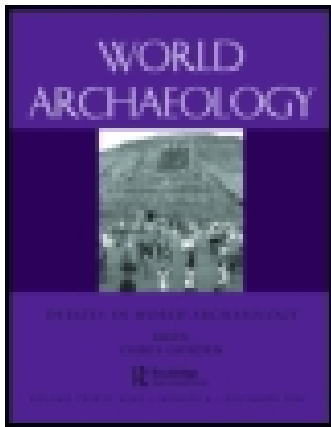
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### The impact of Bayesian chronologies on the British Iron Age

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# The impact of Bayesian chronologies on the British Iron Age

William Derek Hamilton , Colin Haselgrove and Chris Gosden

## Abstract

Radiocarbon dating was long neglected in Iron Age research, with dates on the ‘Hallstatt plateau’ (800–400 BC) considered too broad to be useful compared to artefact typo-chronologies. Such views are now untenable. Around fifty British Iron Age settlements and cemeteries have been dated using Bayesian methodologies, yielding two important general results: (1) typological dating produces sequences that are regularly too late; and (2) many phenomena, from chariot burials to settlement shifts, represent brief horizons, rather than being long lived. Drawing on a selection of studies, this article explores the impact of Bayesian modelling on British Iron Age studies. It highlights potential pitfalls and issues that must be considered when dating the period, illustrates some major successes and looks to the future.

## Keywords

British Iron Age; Bayesian modelling; radiocarbon dating.

## Introduction

For close on a century, complex chronologies have been constructed for Iron Age Britain based largely on artefact typologies. Diagnostic pottery and metalwork have been used to order archaeological sites, tying the material culture of an ‘undated’ Iron Age Britain to the historically referenced chronologies of the Continent, now underpinned by tree-ring dating. While these chrono-typological frameworks have had a deep impact on the Iron Age narrative for southern Britain, they are of less help in northern and western Britain, where metalwork is scarce and pottery

rarely closely dateable. In these regions, archaeologists have more readily embraced radiocarbon dating, but more out of obligation than conviction and usually only to date single sites (Van der Veen 1992 is a rare exception). There have been few attempts at developing independent chronologies for entire regions, let alone for Iron Age Britain as a whole. This is not to say that archaeologists researching the period have not called for more precise chronologies (Haselgrove et al. 2001; Cunliffe 2005), but for various reasons, they are only just beginning to take shape.

### The case for avoidance

Foremost among the reasons behind the historical ‘failure’ of Iron Age radiocarbon chronologies is the well-documented problem with calibrating dates (Haselgrove et al. 2001; Cunliffe 2005, 652–4). This is a direct result of a major plateau in the calibration curve (‘Hallstatt plateau’) between approximately 800 and 400 BC (Fig. 1). When radiocarbon measurements are calibrated and fall within this plateau – a ‘flat’ region of the curve – the effect is to spread out the resultant probability. A ‘wiggle’ at approximately 400–200 BC has a similar effect of smearing time over this 200-year period. In the early days of radiocarbon dating, with 1-sigma errors of 70–100 years on the measurements, these two areas of the curve could actually have a combined effect on the calibration, resulting in a date calibrated to ‘the Iron Age’ but no more. Even two decades ago, the best answer

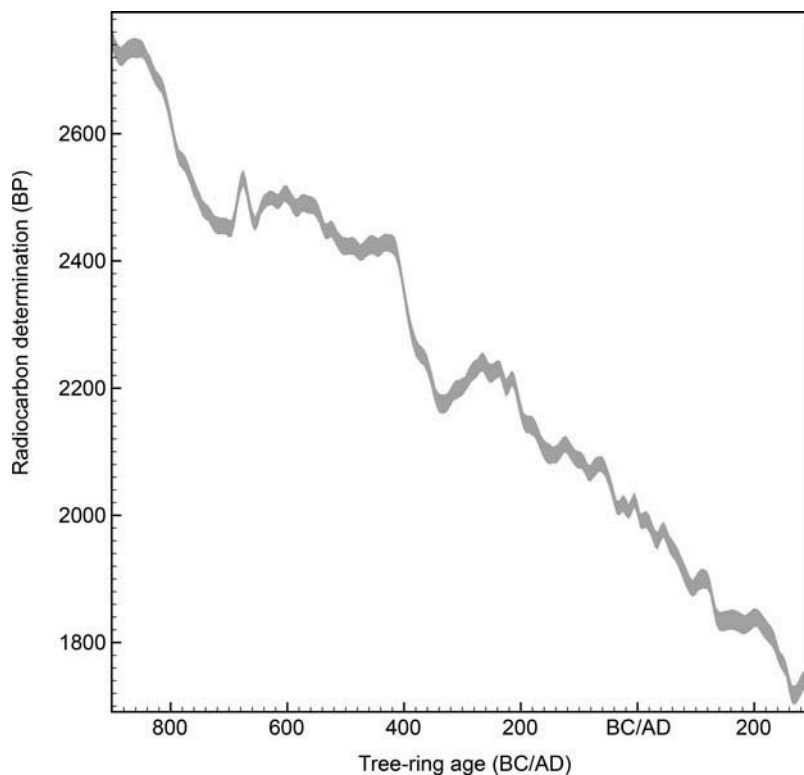


Figure 1 The internationally agreed radiocarbon terrestrial calibration curve (IntCal13) of Reimer et al. (2013) covering the British Iron Age. The Hallstatt plateau can be seen easily as a relatively ‘flat’ area between approximately 800 and 400 BC.

we could often expect was that a site dated either to the earlier or to the later Iron Age. In some regions even this counted as an advance (Haselgrove et al. 2001, 5), but in most it was seen as poor use of scarce financial resources. This problem has been solved in part by progress in measurement precision. Nowadays the 1-sigma errors on individual Accelerator Mass Spectrometry (AMS) measurements from samples of first-millennium BC date are routinely as low as 25–35 radiocarbon years. With this precision or better, many earlier Iron Age results will calibrate to an approximate two-century span covering the first or second half of the Hallstatt plateau. In the later Iron Age the increased precision means that fewer results will calibrate across the entirety of the ‘wiggles’ (Fig. 2).

A second impediment to wider application of radiocarbon dating to the British Iron Age has been a continuing but unwarranted belief in the accuracy of existing artefact chronologies (Haselgrove et al. 2001, 2–3). The argument favouring chrono-typological dating assumes that the process of production, consumption and deposition is fairly well understood, so that an accurate estimate can be made for the date of a context from which material was recovered. It is difficult to say whether this assumption is valid, as few typologies have been adequately independently dated at multiple sites. Another complication with artefact-based chronologies is presented by the potential for residuality through the reworking of deposits or the curation of objects as heirlooms. Consequently, an indirect date from associated material can be misleading. While the complication presented by residuality can be addressed through rigorous appraisal of deposits, the issue of heirlooms is more difficult to overcome.

The problem, in our view, is not so much one of constructing radiocarbon chronologies for the Iron Age *per se* (although the degree of precision is still much diminished for the earlier Iron Age), as a failure to see beyond once valid perceptions to the future of high-precision dating. One of the earliest examples of radiocarbon dating of pottery phases was by Naylor and Smith (1988), who attempted to integrate radiocarbon dates within a Bayesian framework to examine the pottery phasing at Danebury hillfort. Although the authors gave insufficient consideration to taphonomy and the association between the dated samples and the phased pottery, this paper nevertheless paved the way for the future of Bayesian statistics in radiocarbon calibration and dating.

In spite of the enduring perception that radiocarbon is of little utility, a wealth of Iron Age sites have now been dated using a Bayesian approach (Fig 3). In the past two decades, this has been routine for sites that receive funding from English Heritage. Over twenty Iron Age sites

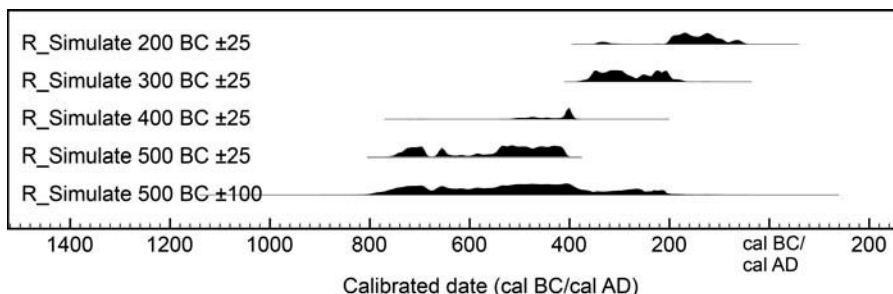


Figure 2 A series of calibrated simulated Iron Age radiocarbon dates. After about 400 cal. BC, most dates with standard precision errors will calibrate to approximately two centuries.

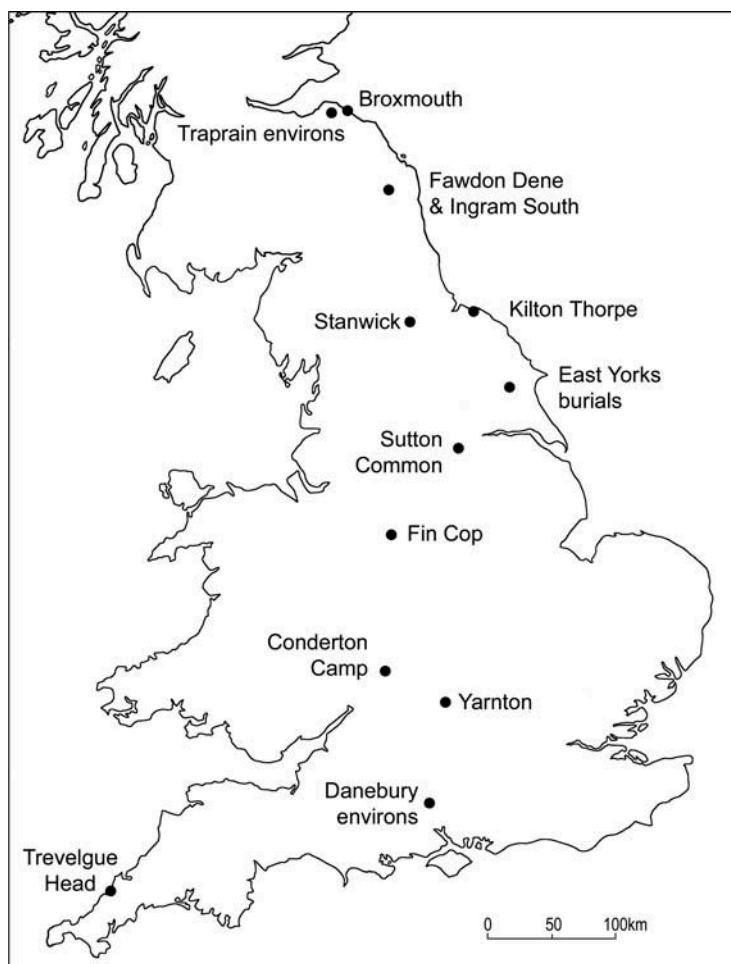


Figure 3 Iron Age sites in Britain with Bayesian chronologies mentioned in the text.

given this treatment include Fin Cop, Derbyshire (Waddington et al. 2012), Sutton Common, South Yorkshire (Van de Noort, Chapman, and Collis 2007) and Yarnton, Oxfordshire (Hey, Booth and Timby 2011) as well as important older excavations such as those at Conderton Camp, Worcestershire (Thomas 2005), and Trevelgue Head, Cornwall (Nowakowski and Quinnell 2011). Historic Scotland has been similarly active in promoting the application of radiocarbon dating to the Scottish Iron Age (e.g. Ralston and Ashmore 2007; Haselgrove 2009); there too, Bayesian modelling is fast becoming routine (Haselgrove 2015, 117–19).

The authors of this article have been involved together or individually, over the past decade, in the radiocarbon dating and modelling of approximately fifty Iron Age sites from across Britain. We will draw on these to explore the impact that radiocarbon dating and Bayesian modelling has had on the Iron Age, illustrating major successes, while highlighting potential pitfalls and issues that must be considered when undertaking these analyses in this period. The majority of our examples relate to settlements, but the radiocarbon dating of cemeteries and contexts yielding decorative metalwork has also had important and unexpected results.

## Robust independent Iron Age chronologies in the twenty-first century

Having countered the myth that radiocarbon dating will never be of more than limited use for the Iron Age, we can turn our attention to how, in conjunction with Bayesian modelling, it is transforming our understanding of this ‘final’ period of prehistory. Here we present three separate, but not mutually exclusive, strands of enquiry that together hold a huge amount of potential for shaping how we understand the British Iron Age.

Our first theme concerns the effect of independent site chronologies on settlement biographies and the established archaeological narratives into which these have been woven. We will illustrate this with reference to two well-known sites excavated last century: Broxmouth in East Lothian and Stanwick in North Yorkshire. Our second strand relates to the adequacy of existing chrono-typological frameworks. As we noted, this requires independent testing, but direct dating of diagnostic artefacts is rarely possible. What we can do is to devise dating programmes to test our beliefs. Alternatively, we may be able to ‘date’ artefacts from a site-based model. The ‘Dating Celtic Art’ project exemplifies the first approach, while the opportunistic modelling of burials in East Yorkshire is used to illustrate the second.

Third, it is important to emphasize that radiocarbon dating and Bayesian modelling are not simply tools for estimating *when* things occurred. We can move beyond the timing of simple ‘events’ and estimate the periodicity of specific structural developments, such as the average lifetime of houses. In this way, we can begin to use chronology as a tool for teasing apart processes at play in the past. To illustrate this theme, we will examine the tempo of change at selected settlements in north-east England and south-east Scotland.

### *Reinterpretation and the development of new site-based chronologies*

One of the strongest impacts that Bayesian modelling has so far had on the British Iron Age has been in enabling us to refine the chronology of sites that were excavated before the use of radiocarbon became widespread.

For more than three decades, the hillfort of Broxmouth has been central to debates about Iron Age settlement and society in southern Scotland (e.g. Harding 1982; Dunwell 2007). The large-scale excavation of this site in the 1970s helped bring about the final collapse of the prevailing ‘Hownam’ model for the development of hillforts in the region. This model originated in the 1940s, when cross-dating with southern England seemed to offer a feasible way of establishing a chronology for Scottish hillforts, most of which yielded few if any datable artefacts (Harding 2004). It envisaged a simple progression to ever grander enclosure (Armit 1999), but the Broxmouth sequence proved much more complex: an initial undefended settlement was later enclosed by successive ramparts, some univallate, others bivallate, apparently punctuated by periods when the defences were left to decay and ending with another unenclosed phase (Hill 1982). However, with few radiocarbon dates, the timing of these different phases remained very largely a matter of conjecture, nor was it possible fully to exploit the potential of the unusually large artefact and environmental assemblages found in the excavations.

An extensive programme of radiocarbon dating (in two tranches) and Bayesian modelling for the final publication has at last allowed a robust chronological framework to be constructed for Broxmouth. In all, 158 determinations were obtained, as far as possible from long stratigraphic ‘chains’ (Armit and McKenzie 2013, 191–224). This permitted the delineation of a sequence



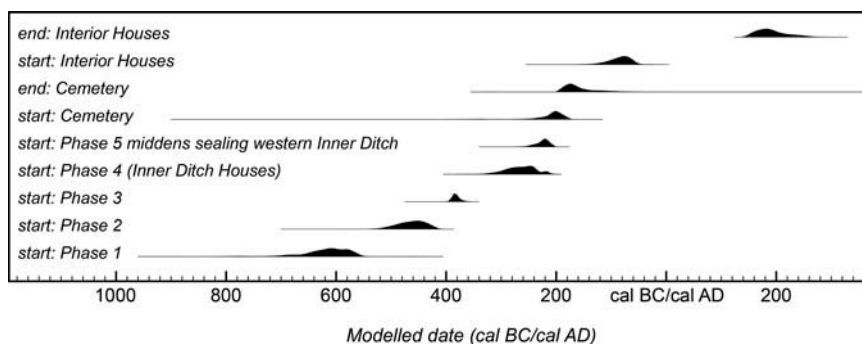


Figure 4 Model estimates for the major phase boundaries at Broxmouth, along with dates for the start and end of the cemetery and the Phase 6 houses (Armit and McKenzie 2013, illus. 9.12). Hill (1982, 184) suggested that Broxmouth was occupied for most of the first millennium BC and the first two centuries AD, without further refinement.

spanning most of the Iron Age, divisible into six main structural phases. Occupation probably began in 640–570 *cal. BC* (68 per cent probability; Fig. 4; start: Broxmouth), with the building of a palisaded enclosure, later overlain by the houses of Hill's early unenclosed settlement. Phase 1 ended in 490–430 *cal. BC* (68 per cent probability; start: Phase 2). The hillfort (Phases 2–3) had at least six sub-phases, after which the settlement first expanded over the old defences and then contracted (Phases 4–5). At this point, the settlement was once again enclosed, but only with a low bank (Phase 6); it was abandoned in *cal. AD* 155–210 (68 per cent probability; end: interior houses). Later activity was confined to a single burial.

Undoubtedly the most important outcome of the Broxmouth study is in demonstrating conclusively that, where adequate stratigraphic controls exist, even occupation phases entirely on the Hallstatt plateau can be successfully dated. In addition, the modelling was instrumental in teasing out the sequence of digging and infilling of the ditches. This was not only more complex than the excavator had thought but also took place in a different order (Armit and McKenzie 2013, 224). The Bayesian approach was not initiated until after the second tranche of dating and it was in large part due to the rigorous sample selection process required for robust Bayesian models, especially the incorporation of dates on articulated mammals in the ditch deposits, that the full temporal complexity of the sequence was revealed. Other outcomes included linking a short-lived cemetery outside the site with a specific phase of settlement (see also Armit et al. 2013) and placing Broxmouth in a historical framework, by showing that, contrary to the assumptions of earlier generations, the site continued to be inhabited after the region was occupied by the Roman army and was actually abandoned in the interval between the Antonine withdrawal (*c.* AD 165) and the re-invasion by Severus (AD 211). Last but not least, the modelling has provided a robust chronological framework for the rich material culture assemblage, with potential ramifications for the dating of objects elsewhere.

Ever since Sir Mortimer Wheeler's excavations in 1951–2, the Stanwick earthworks have figured prominently in narratives of the Brigantes, who inhabited north-east England, between the Roman invasion in AD 43 and the annexation of their territory in the AD 70s (e.g. Mattingly 2007). Wheeler's (1954) three-stage sequence for Stanwick was drawn straight from the Roman historian Tacitus and the events he describes. At the most basic, by AD 51 at latest, Cartimandua,

ruler of the Brigantes, had become a client of Rome; with Roman assistance, she remained so until *c.* AD 69, when she was ousted by her ex-consort, Venutius, who had become a focus of anti-Roman resistance in the tribe (*Histories* 3.45). Wheeler viewed the earthworks as built for defence and deduced that Stanwick was the stronghold of Venutius. This narrative guided much of the interpretation of Wheeler's limited excavations and led to a chronology that compressed the development of the complex into a mere three decades between *c.* AD 40, when a small fortification was built in the Tofts, and the inferred storming of Venutius's much-enlarged stronghold by the Romans in AD 71. Archaeological corroboration was provided by the discovery of Roman imports in the perimeter ditch and in the Tofts.

Renewed excavations in the 1980s revealed that settlement in the Tofts spanned a longer period (Haselgrove, *forthcoming*). The sequence is complex, with structures rebuilt and ditches dug multiple times. In all, five main structural phases can be discerned. Radiocarbon dates obtained in the 1990s from Period 1 features suggested that the settlement originated in the first century BC, but the dating of later periods relied on Roman imports. From these, it was inferred (a) that the settlement was reorganized soon after the invasion in AD 43 and (b) that frenetic building activity represented by Periods 4 and 5 spanned the decades when the Brigantes were allies of Rome, an interpretation of the archaeological evidence that seemed just as compatible with Tacitus's narrative as Wheeler's.

A new dating programme has enabled an independent chronology to be developed for the Tofts based on fifty-eight dates from three interlinked sequences. This confirms that occupation probably began in 75–50 *cal. BC* (68 per cent probability; Fig. 5; *start: Stanwick*), but has radically altered the dating of Periods 4–5. Enclosure 3, marking the start of Period 4, was constructed by 50–25 *cal. BC* (68 per cent probability; *build Enclosure 3*), fifty years earlier than inferred from the handful of imports in Period 4 contexts. The first of two monumental structures outside Enclosure 3 and the rampart enclosing the Tofts were built around the same time, three-quarters of a century earlier than Wheeler believed. The span of the ditched phase of Enclosure 3 is estimated as 5–35 *years* and its palisaded phase as 10–40 *years* (both 68 per cent probability), giving it a span of two to three generations. The Period 4 imports were re-examined in the light of this model, and it became clear that their original Claudian dating, while technically possible, was unduly influenced by the historic framework; there is nothing to preclude them being late Augustan and Tiberian products (Haselgrove, *forthcoming*).

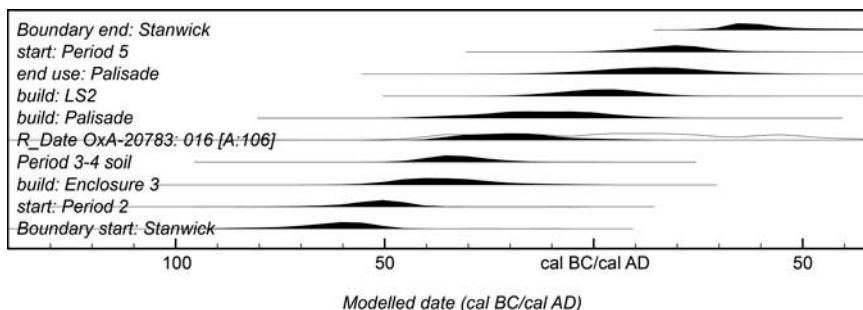


Figure 5 Probability distributions for identified events in the use-life of the Tofts settlement at Stanwick as derived from the chronological model (Haselgrove, *forthcoming*, Fig. 7.6). Prior to radiocarbon dating, the events modelled here apart from *start: Period 2* were attributed to period *c.* AD 40–70.

The final phase in the Tofts (Period 5) saw widespread building in stone. According to the model, dated activity ended in *cal. AD 25–50* (68 per cent probability; Fig. 5; end: Stanwick). This seems early given the quantity of Neronian samian (AD 55–70) in the latest deposits. Few radiocarbon dates could be obtained from these levels, which may explain the disparity. In any case, the 95 per cent probability estimate of *cal. AD 20–80* for the end of occupation comfortably accommodates the samian, while reinforcing other indices suggesting that the Tofts was abandoned before the Roman advance into northern England. Moreover if the array of highly unusual imports from Period 5 were, as seems likely, diplomatic gifts, and Stanwick was the seat of the pro-Roman Cartimandua rather than Venutius (Haselgrove, forthcoming), an early end to the site would fit with Tacitus's tale of Roman intervention precipitated by the collapse of the client kingdom.

While this last point can be argued, the repercussions of the model, in terms of repositioning Stanwick within the context of Roman expansion and creating a new narrative for late Iron Age Britain, are far reaching. Far from owing its existence to the period of campaigning that followed the invasion in AD 43, Stanwick was already an important place a century earlier. It can be compared to the enclosed *oppida* that emerged in southern Britain at this time (Cunliffe 2005) and to monumental centres like Navan and Dùn Ailinne in Ireland (Lynn 2003), symptomatic of the social and political changes under way in both islands. Equally important is the presence of Augustan imports at Stanwick, potentially contradicting current wisdom that Roman interests were then confined to southern England. Having identified one well-connected focal site of this date in northern England, it is likely that more will be found. At the same time, it is not difficult to think of other important Iron Age sites where an independent chronology could change radically our perception of their development and context.

#### *Questioning the timing and utility of existing chrono-typologies*

At the risk of alienating ourselves from colleagues, we suspect that some of our basic chrono-typologies are in need of repair. This is not to say they are massively in error, but the accuracy of the dates and the degree of precision we often place upon them may not always be congruous with one another. If so, we run a risk of producing deficient, and possibly outright defective, narratives.

The development of programmes to date chronologically sensitive artefacts independently is one way to ensure a high level of confidence in our conclusions about the timing of sites and events and their relationship across the landscape at varying scales – be this a region, country or even continent. To show how important this is, we will examine two studies utilizing radiocarbon dates on samples associated with Iron Age metalwork in closed contexts in the modelling process

The 'Dating Celtic Art' project (Garrow et al. 2009) was conceived to explore the chronology of the six Iron Age decorative metalwork styles recognized in Britain (Stages I–VI; see Stead 1996). A primary aim was to redress shortcomings identified with the chronological linking of the British metalwork to La Tène art in continental Europe, notably the lack in the insular sequence of securely dated objects from the fourth to second centuries BC. The project was partly designed to complement the ground-breaking study by Needham et al. (1997) who published the first independent chronology for British metalwork assemblages from the middle Bronze Age to the Llyn Fawr phase of the Early Iron Age.

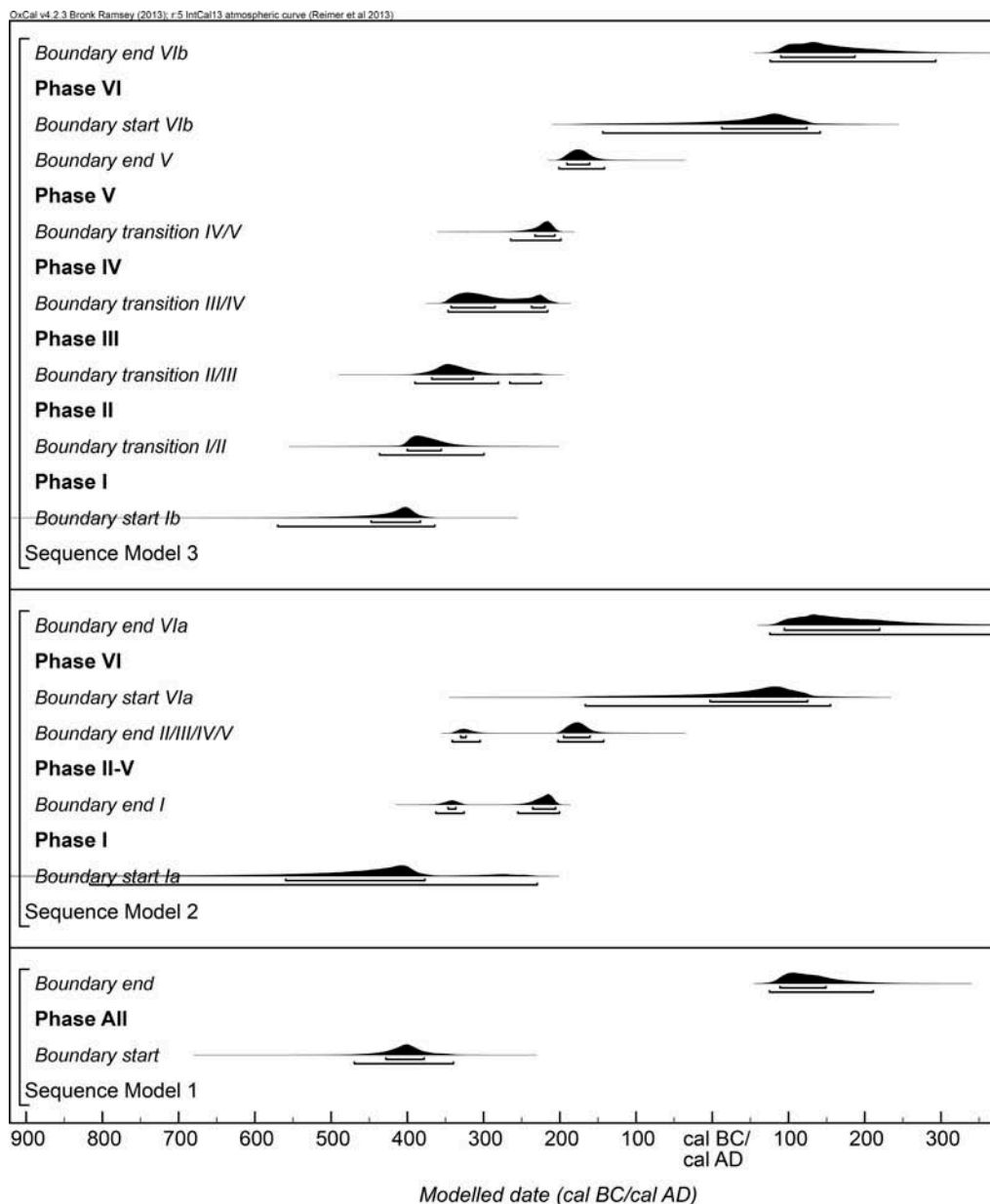


Figure 6 Results of applying three different Bayesian models to the radiocarbon dates obtained by the ‘Dating Celtic Art’ project (after Garrow et al. 2009, illus. 3). The modelled start dates for Stages II–V are up to a century earlier than those inferred on typological grounds and the estimated end date for Stage V closer to two centuries (see text)

Using forty-seven radiocarbon determinations on thirty-six contexts with metalwork, Garrow et al. (2009) developed three Bayesian models (Fig. 6). These ranged from regarding all the dates as a single continuous phase, to treating the six phases as sequentially ordered. Each model suggested that the samples dated range from approximately 400 cal. BC to some time in

the second century cal. AD. Ultimately, their preferred Model 2 used three phases, where the first phase contained objects belonging to Stage I, the second phase objects of Stages II–V and the final phase objects of Stage VI, with a modelled gap between it and the preceding material (ibid., 99). This hiatus spans the period *c.* 175 cal. BC–cal. AD 75, with a notable dearth of determinations in the late first century BC and the early first century AD.

It remains to be seen how real this gap is – it might be a function of what the project was able to date or reflect changes in depositional practices – but the results show that we should be cautious in assuming continuity in the production of decorated metalwork, particularly in a period when new types of valuables like coins were coming into wider use. Other important outcomes were to confirm the early appearance of La Tène art in Britain and to suggest that Stages II–V were not strictly successive, as critics had argued (Macdonald 2007). Thanks to the dating, we can now see that the flowering of motifs viewed as the real mark of insular La Tène art such as basketry hatching and triskeles took place when contact with the Continent is least evident (325–150 BC), thereby transforming our understanding of the context in which British decoration achieved its distinctive forms (Garrow and Gosden 2012).

Jay et al. (2012) had different questions and thus a different approach. This study focused on the Iron Age cemeteries, including ‘chariot’ burials, at Wetwang and Garton Slack in East Yorkshire, belonging to what is generally known as the ‘Arras culture’. Chariot burials were at their peak on the Continent in a zone extending across northern France to the middle Rhine in La Tène A, equivalent to the mid–late fifth century BC (Diepeveen-Jansen 2001), although later examples do occur. British archaeologists have long assumed that the Yorkshire chariot rite ultimately derived from the continent and that the ensuing ‘Arras’ burials spanned the later first millennium BC. Based largely on associated brooches, Dent (1982, 1984) proposed a date from the fourth to first centuries BC for Wetwang, the largest ‘Arras’ cemetery yet excavated.

For East Yorkshire, four interconnected models were constructed and run together within a single model plot: one each for dated burials grouped in the Wetwang and Garton cemeteries (both treated as unordered phases), one for chariot burials and one using the typology of brooches from dated graves as priors. Connections occurred where a burial existed in more than one model. The modelling suggests that the primary use of the Wetwang cemetery was confined to the third and earlier second century cal. BC, a period of only three to five generations, far shorter than Dent supposed, although other undated cemeteries in East Yorkshire could begin earlier or end later. Also contrary to expectation, the ‘chariot’ burials apparently had a very short floruit of no more than a few decades either side of 200 cal. BC, a full two centuries after their inferred continental parents, thereby severing a key argument for the rite having been introduced by incomers from northern France. Lastly, the insular involuted brooches in the Yorkshire burials (Fig. 7) have, through stretching their chronology, been dated too late to fill the gap between the prototypes and the advent of new types in the first century BC (Jay et al. 2012). Consequently, the study has opened up another gap in a different type of metalwork, corresponding to the earlier part of the hiatus identified by Garrow et al. (2009) and broadly equating to La Tène D1 in Europe (*c.* 150–85 BC). Most of the dates were obtained by Jay and Richards (2006) for a study of diet and did not seek to exploit the burial chains that exist at Wetwang; a study targeting these is likely to result in a significant further gain in precision.

For the present article, we undertook a brief comparison of the modelling from the ‘Dating Celtic Art’ and East Yorkshire projects, as a number of determinations on graves

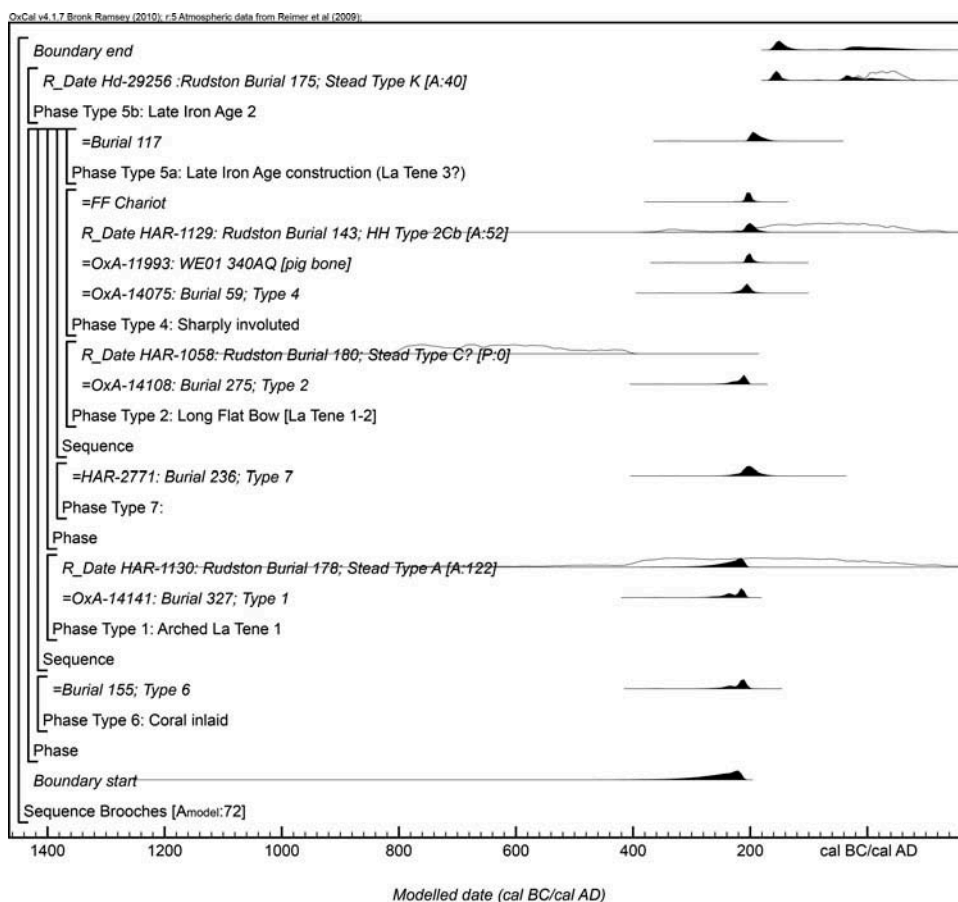


Figure 7 Chronological model for the dated Iron Age brooch types, directly subset from the combined model generated for the East Yorkshire project (Jay et al. 2012, Fig. 9). Involuted brooches (Type 4) have generally been dated to the second and first centuries BC; one-piece brooches (Type 5) no earlier than the first century BC.

obtained in the first study were used again in the second. The metalwork from these graves was given a ‘Stage V’ classification. A simple Bayesian model was constructed from these dates, placing them all in an unordered group with a start and end boundary. The results suggest that Stage V began in 380–320 cal. BC (13 per cent probability; Fig. 8; start: Stage V) or 275–200 cal. BC (82 per cent probability), and probably in 245–205 cal. BC (68 per cent probability). Stage V ended in 340–315 cal. BC (3 per cent probability; end: Stage V) or 205–100 cal. BC (92 per cent probability) and probably in 195–155 cal. BC (68 per cent probability). These results are similar to those obtained by Garrow et al. (2009), who discuss the earlier dating indicated for some of the burials. A comparison of modelled probability density functions for the chariot burials is given in Figure 9. While the probabilities derived from the burials-based models are more precise, the overall results, from data modelled in quite different ways, add weight to the argument that the chariot burials were a short-lived phenomenon, and further illustrate the



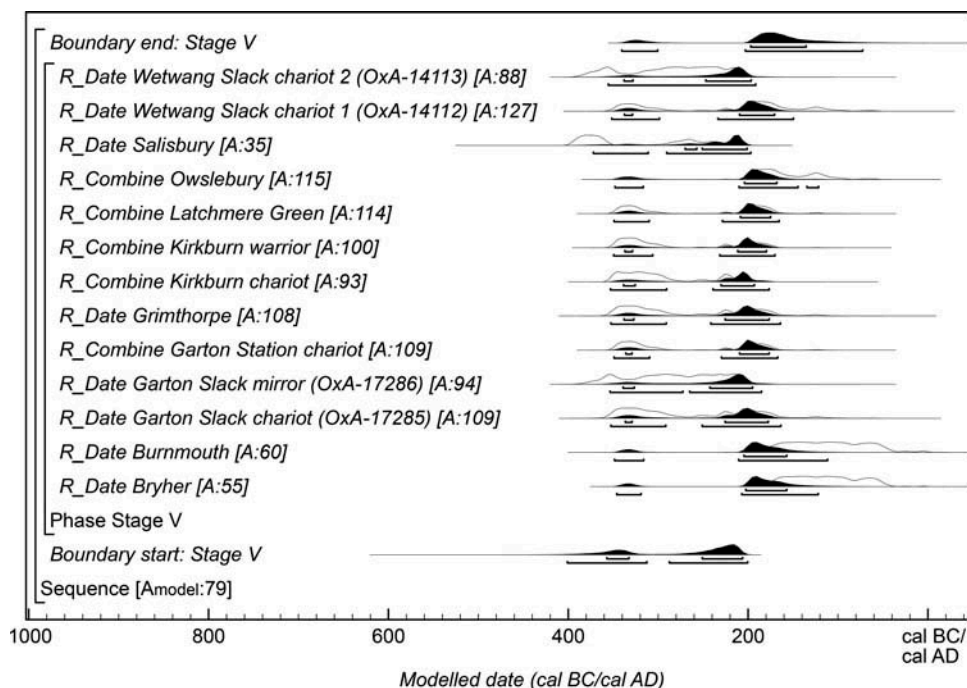


Figure 8 Simple Bayesian model for 'Stage V' Celtic art in Britain. The model was created in OxCal (Bronk Ramsey 2009) using data presented in Garrow et al. (2009). Objects with Stage V decoration are generally attributed to the second and first centuries BC.

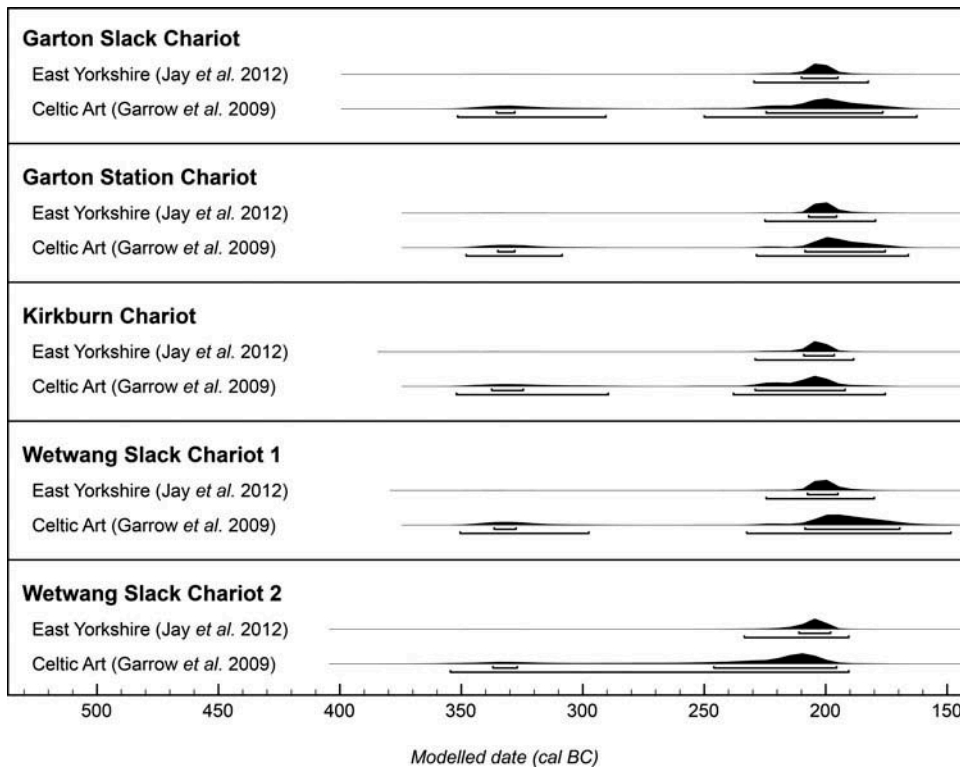
importance of looking at the same questions from different perspectives and with different archaeological data.

Radiocarbon dating has the potential to corroborate or challenge many current beliefs through the generation of robust chronologies for artefact types deemed to be temporally distinctive. By independently 'testing' the chronological positioning and sensitivity of the artefacts that we regularly use to develop narratives for sites and regions, we can determine where our arguments may falter. Furthermore, we can use multiple lines of evidence to enhance our stories and strengthen our chronological resolution.

### *The tempo of change*

The adoption of Bayesian approaches has also started to change the way that we perceive the timing of transformations in the Iron Age, permitting archaeologists to move beyond simply dating 'events' and explore rates of change and the tempo of processes. The modelling of the timing of key changes at Broxmouth and Stanwick highlighted how important this is for understanding the dynamics of a specific place, while the work of Hamilton (2010) has extended the discussion from settlements to specific types of features by examining the renewal of ditches and roundhouses across a selection of sites.

The chronological model for Stanwick estimated that the settlement in the Tofts spanned 65–160 years (95 per cent probability), probably around 80–120 years (68 per cent probability).



*Figure 9* Comparison of the modelled probability density functions for the chariot burials at Garton Slack, Garton Station, Kirkburn and Wetwang Slack Chariots 1 and 2. The probabilities presented for Garrow et al. (2009) are derived from the OxA- measurements presented in Fig. 8 of this article, while those for Jay et al. (2012) are extracted directly from the final model presented in that paper. Hitherto the chariot burial rite was thought to extend from the fourth to the first centuries BC.

As there are five archaeologically defined periods, this implies that major structural changes occurred at intervals of roughly fifteen to thirty years. This level of dynamism is in sharp contrast to the prevailing view of prehistoric space as conservative. At this pace, we start to appreciate that elements of a settlement fall into disrepair and need replacing, ditches silt up and have to be re-cut, spatial demarcations are altered to remain fit-for-purpose and new houses built to accommodate the next generation. Against this backdrop we can begin to see Iron Age agents carrying out the routines of their daily lives.

Dating of Iron Age farms in north-east England and south-east Scotland suggests that enclosure ditches were remodelled or re-cut around every thirty to forty years (Hamilton 2010). While some of the examples were full re-cuts, the ditch digging that showed the fastest tempo of change involved reorganization of internal space, as at Ingram South, Northumberland, but also at Stanwick before the Tofts was fortified. The data for the rebuilding of roundhouses at settlements across the region are just as telling. The use-life of approximately one generation for these buildings accords closely with the enclosure data. The settlement at Kilton Thorpe, Redcar, had a life of only 28 years (median value; *Kilton Thorpe (one phase of houses)*). There is no indication that the builds were successive.



At Stanwick, the first monumental structure was used for 34 years (median value; *Stanwick LS1*), its successor for only 17 years (median value; *Stanwick LS2*). There is nothing to indicate why LS2 was dismantled so soon, but it is significant that this preceded a major reorganization of the entire area. Most striking of all is the evidence from Fawdon Dean, Northumberland. Here two timber roundhouses (CS1–2) were both burnt to the ground, whether accidentally or on purpose, prior to the construction of the stone-built settlement. Both the archaeology and the dating suggest that this was the same singular event. The interval for CS1 P2 is 41 years (median value; *Fawdon Dean CS1 P2*) and CS2 P1 is 39 years (median value; *Fawdon Dean CS2 P1*). These results for Iron Age houses contrast with the modelled results for Late Bronze Age roundhouses at Bestwall Quarry, Dorset, which clearly stood for at least a couple of generations, perhaps around seventy years or so, before being completely rebuilt (Bayliss et al. 2009).

Explanations for the tempo of change can be functionally and socially derived. It is entirely possible that a ditch could fill in suddenly, perhaps after a storm, necessitating a full re-cut. On the other hand, cleaning of ditches is often apparent in the archaeology, implying that the mobilization of labour to dig ditches had a strong social component irrespective of the degree of infilling. Similarly, rebuilding a roundhouse must have required a substantial input of human labour, not only in the physical construction but also in the acquisition of raw materials. The investment of labour is such that building a house would need to take place either over an extended period of time with the occupants doing the work or over a few days with the neighbours lending a hand – an Iron Age version of an Amish ‘barn raising’. The former scenario places a settlement in greater isolation in the landscape; the latter acknowledges and reinforces the interconnectedness of the community. The fact that many Iron Age roundhouses were rebuilt on a generational timescale suggests an important familial aspect to the process, which, if undertaken at a communal level would also strengthen wider ties.

## Conclusion

To date, Bayesian modelling on British Iron Age sites has been, more or less, one site at a time, thereby lacking a coherent research design aimed at using site chronologies to explore how society operated and interacted across a landscape. The authors are undertaking a project, funded by the Leverhulme Trust, to develop independent chronologies for Iron Age sites around Danebury in Hampshire. Our aim is to gain better understanding of the timing of construction, remodelling and abandonment events at each site and how archaeologically visible transformations relate to one another across the region. Iron Age settlements in north-east England show a surge in enclosure c. 200 cal. BC and an equally abrupt shift away from enclosure c. 50 cal. BC (Hamilton 2010), in both cases probably socially induced. The results of the Danebury project will, we hope, form a springboard for revisiting some of the typological sequences and social interpretations generated by the fieldwork (e.g. Cunliffe 2009) and for developing new perspectives on settlement dynamics in the hillfort environs.

This landscape approach to refining settlement and artefact chronologies across regions must continue. Although the Danebury project will reach into the Roman period to some extent, much more work can be done on later Iron Age and Roman interaction. Here archaeologists have a real difficulty in marrying the generally coarse prehistoric chronologies offered by one or a few radiocarbon dates with seemingly precise chronologies founded in historical dating and typo-chronologies. As we saw above, supposed links drawn between Britain and the continent have

had unfortunate consequences for insular chronologies, which have been erroneously expanded or compressed to fit expectations. However, both the ‘Dating Celtic Art’ and East Yorkshire studies uncovered important issues in the dating of material by reference to the continent. Projects to develop independent regional chronologies and to ‘calibrate’ existing typo-chronologies would undoubtedly be beneficial on both sides of the Channel.

This article has necessarily focused on a handful of case studies, but there are many other examples that we could have employed to emphasize the same outcomes. One need look no further than other sites mentioned in passing earlier in the article. At Sutton Common, radiocarbon dating and Bayesian modelling showed that the outer defences were all built within twenty years of the original box rampart (Van de Noort, Chapman, and Collis 2007, 93–5), rather than elaborated over a longer period as might have been supposed. The short-lived middle Iron Age inhumation cemetery at Yarnton was attributed to the Anglo-Saxon period until radiocarbon dating proved otherwise (Hey, Booth and Timby 2011, 333–43), with implications for the dating of unaccompanied inhumation burials throughout the middle Thames valley, where Iron Age cemeteries were previously unknown. Conversely, at Standingstone in East Lothian, a circular enclosure regarded as Iron Age on morphological grounds was radiocarbon dated to the tenth to ninth centuries cal. BC, placing it in the same late Bronze Age horizon as the well-known ring-forts of eastern England such as Mucking and Thwing (Haselgrove 2009, 193–6), to which it could conceivably be related.

At Trevelgue Head, dug in the 1930s, scientific dating of pottery from the midden deposits has been used to support the development of style within the South Western decorated pottery tradition; ‘transitional’ style vessels were produced by the fourth century cal. BC, while the ‘standard’ style ended in the first century cal. BC (Nowakowski and Quinnell 2011, 141–5, 163–85), both earlier than was thought before the advent of radiocarbon dating. Our ongoing work in the Danebury area suggests that Bury Hill hillfort was occupied in the second rather than the first century BC, confirming the earlier dating for decorated horse and chariot equipment deposited in the interior indicated by the Celtic Art project (Garrow et al. 2009). Lastly, at Conderton Camp the modelling provided an earlier than expected date for the building of the hillfort and strongly suggests that in places the relative order of structures suggested from the pottery may be incorrect (Thomas 2005, 237–45).

Notwithstanding the important advances in understanding that they have already generated, two challenges exist to the further development of Bayesian chronologies. First, there is a real dearth of capacity. We have moved beyond simply ‘eye-balling’ calibrated dates, and are now employing complex and sophisticated statistical tools to explicitly model our data. Not everyone, however, has the necessary training and experience to analyse radiocarbon dates using Bayesian tools. As with pottery or faunal analysis, it must be recognized that building archaeological chronologies is a specialism that requires a period of experiential training before individuals are in a position to work on their own.

An even greater challenge to the development of more refined independent chronologies is funding. It is important that archaeologists are realistic in their expectations of scientific dating. They should not, for example, promise generational precision for early Iron Age sites without first undertaking simulations to see what is possible with the stratigraphic sequences that exist. We also need to avoid the trap of thinking about dating at the end of a project, and instead wherever possible build project aims and research questions around the possibilities for scientific dating. For funding bodies to be on-board with providing the sums necessary for developing robust chronologies, dating programmes in grant proposals need to be thoroughly thought out beforehand. Through a combination of experience of working in the period and the simulation tools available in programs

such as OxCal, it should be feasible with most research funding applications to develop realistic estimates for the number of dates required to obtain a specific degree of precision. Most excavations on Iron Age sites, however, are development-led. It is vital that curators and contractors are (made) aware of the vastly enhanced potential of radiocarbon dating for the period; that the requirement for absolute dating is written into project briefs and post-excavation designs; and that intervention strategies are sufficiently flexible to exploit opportunities for dating that arise in the field.

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No potential conflict of interest was reported by the authors.

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