Northern Bridge Consortium
Collaborative Doctoral Awards
Competition (Staff-led)

NORTHERN BRIDGE CONSORTIUM DOCTORAL TRAINING PARTNERSHIP

Project Proposal Application

To be completed by the lead proposed supervisor, with input from the non-HE Partner Organisation(s).

UKRI Arts and Humanities Research Council

SECTION 1: PROJECT SUMMARY AND APPLICANT DETAILS			
Proposed Project Title:	**Technological choice and variability in prehistoric metalworking: a transdisciplinary investigation**		
Project Summary: *(Maximum 100 words)*	The project investigates variability and social choice in prehistoric metalworking through an innovative transdisciplinary approach that integrates experimental archaeology, materials science, and a critical review of social studies on craft practice. The student will develop a novel understanding of artisan skill, sensory perception, communities of practice, and craft specialisation in prehistoric bronzeworking. The research will provide new insights into the social context of early European metallurgy, reassessing the enduring link between metallurgy and the rise of social complexity. Through this work, the student will acquire a unique transdisciplinary skillset that will significantly enhance their intellectual profile and employability.		
Host University:	Newcastle University		
Name of Non-HE Partner Organisation(s): *(Add more lines if needed)*			
1. ISIS Neutron and Muon Source, Rutherford Appleton Laboratory, STFC, UKRI.			
2.			
Contact(s) at Non-HE Partner Organisation(s): *(Add more lines if needed)*			
Name:	Dr Antonella Scherillo	Email:	
Name:		Email:	
Primary AHRC Subject Area: *Select one subject area from the list here. Please do not add or amend subjects, as there will not be a corresponding Subject Area Review Panel to assess your nomination.*		Archaeology	
Does the project include a Creative Practice component?		YES ☐	NO ☒
Do you consider the project to be interdisciplinary?		YES ☐	NO ☒

If you consider the project to be interdisciplinary, please state why: *(Maximum 100 words. Please note that your application will be assessed by the relevant **primary AHRC subject area review panel**. However, in this space you should indicate which other subject areas your proposal covers and how your methodology is genuinely interdisciplinary.)*

SECTION 2: PROJECT PROPOSAL AND CASE FOR SUPPORT

Please provide full details of the proposal and make your case for support below:
(Maximum 750 words)

Introduction and significance

This project aims to revolutionise our understanding of the socio-technological dimensions of craft practice through in-depth research on early bronzeworking. Archaeologists have long grappled with the **perplexing technological variability evident in prehistoric bronzes**, even within a single region, period, or object category. For instance, Chalcolithic axes from the northern and southern Alps exhibit distinct working methods (Dolfini 2014; Kienlin 2010), while Bronze Age swords display varying edge-hardening treatments, some more efficient than others (Hermann et al. 2020). **What accounts for such variability?** Is it a reflection of regional preference for specific technological processes? Workshop traditions? Object customisation? Or the skill of individual bronzesmiths? To answer these questions, the student will investigate technological variability in Chalcolithic and Early Bronze Age (EBA) metalworking in Britain, *c*.2500-1500 BC. The study focuses on axes and daggers – two object categories that display considerable, yet understudied, intra-category variation.

The project is theoretically grounded in an original cross-fertilisation of Kuijpers' (2018) work on **perceptive categories** – how smiths assess technological parameters through sensory experience – and Lemonnier (1993) and Latour's (1996) explorations of **technological choice**, emphasising that human societies adopt technical behaviours for quintessentially social reasons. The student will explore these concepts through an **innovative transdisciplinary approach bridging materials science, experimental bronzeworking, and social studies on craft practice**. By researching variability, skill, and technological choice in prehistoric metallurgy, the student will address broader questions about human engagement with the material world and **provide novel insights into the social context of prehistoric metallurgy**. Furthermore, by creatively engaging with lab-based materials analysis, workshop-based craft practice, and desk-based materiality studies, the student will acquire a unique transdisciplinary skillset that will significantly **enhance their intellectual profile and employability**.

Research questions

Q1. What is the degree of variation in annealing and work-hardening in Chalcolithic and EBA bronzes, and how does it vary regionally, over time, and within/across object categories?

Q2. How do scientific data about annealing and work-hardening translate into perceptive categories as revealed by experimental bronzeworking, e.g., through visual and aural clues?

Q3. Are there any spatial, chronological, or object-based data patterns that might indicate distinctive bronzeworking traditions and social choices? What do these patterns suggest about the social context of bronzeworking?

Research methods and project timeline

These questions will be addressed through an **integrated multi-method approach**: (1) a review of published microstructural data on Chalcolithic and EBA axes and daggers, providing a technological baseline for the research; (2) new metallographic and Neutron Diffraction (ND) analyses of 40 objects representing the main types and regions (SW, SE & Northern Britain); (3) reflexive bronzeworking experiments replicating the microstructures identified through (1) and (2); and (4) a critical reassessment of social studies on craft skill, choice, and perception.

- **Year 1**: The student will train in metallography at Newcastle and ND analysis at ISIS. These complementary methods will reveal the technological processes behind metalwork microstructures (e.g., the extent of cold working and annealing) informing smiths' working choices. The student will also review the literature on microstructural data.
- **Year 2**: At Newcastle, the student will analyse c.30 unpublished metallographic samples of axes and daggers from Emeritus Professor Northover's personal collection. At ISIS, they will conduct non-invasive ND analysis of 5 axes and 5 daggers loaned from the British Museum. Subsequently, they will engage in experimental bronzeworking under Dr Christina Clarke (ANU), who will be seconded to Newcastle. They will cast and work several replica axes and daggers, varying key parameters meaningfully (e.g., hammering/annealing cycles). They will then perform metallography and ND analysis on the replicas and compare this data with that obtained from archaeological objects.

- **Year 3**: The student will critically reflect on their experimental practice, focusing on how scientific data translate into perceptive categories. This will inform a broad reassessment of the social context of technology and craftsmanship, thus developing the project's intellectual framework and answering the research questions.

Project outcomes

This project will establish a **novel interpretative framework for understanding the interplay between metallurgical practice and social change** in prehistoric Europe. The findings will be disseminated through an original PhD thesis and 3 peer-reviewed journal articles. By translating scientific data into sensorial craft practice, this research will illuminate the social context of prehistoric bronzeworking, focusing on smiths' skill, object customisation, communication among communities of practice, regional and super-regional connectivity, and craft specialism. These insights will **significantly enrich the debate surrounding metalworking in prehistoric Europe, challenging stale binaries** (e.g., specialist/non-specialist) and **re-examining the enduring link between metallurgy and social inequality**, which rests of the idea of metalworking as an inherently complex specialist craft.

Provide details of any resources and facilities, including equipment, fieldwork, training, etc., that will be required to complete the project successfully. NBC has limited Research Training Support Grant funding, which may affect the feasibility of high-cost projects. Please note where you might also secure additional funding, (e.g. partner organisations; department or school). Include estimated costs:

(Maximum 200 words)

A world-class network of international researchers will provide the student with multidisciplinary training, access to cutting-edge analytical facilities, and valuable networking opportunities. Dolfini (lead supervisor, Newcastle), an archaeologist, will offer expertise in **prehistoric archaeology, metallurgy, and social studies**, facilitating access to state-of-the-art analytical and experimental equipment from NeMCAS Facilities at no cost to NBC. Charles (second supervisor, Newcastle), an engineer, will deliver **metallographic and SEM-EDX training**, with machine time subsidised at £40 per hour for up to 30 hours (£1,200 total, covered by NBC). Scherillo (ISIS) will train the student in **ND theory and data interpretation** at no cost to NBC; she will also supervise the student during ISIS experiments and data analysis. Clarke (ANU) will provide **voluntary training in experimental bronzeworking** during a yearlong Visiting Fellowship at Newcastle (materials funded by NBC); EXARN, Newcastle's PhD-led experimental archaeology network, will support their work. Northover (formerly Oxford) will **grant access to metallographic samples** from his personal collection and offer guidance on the interpretation of microstructural data at no cost for NBC. Wilkin (British Museum) will facilitate access to the museum's world-class Bronze Age collections and **advise the student on artefact loaning**, which is required for ND analysis at ISIS.

Outline the arrangements for communication between the non-HE partner organisation and the academic host institution in regard to project management and monitoring academic progress:

(Maximum 200 words)

Dolfini, the lead supervisor, has established connections with all institutions involved in the project, allowing the student to benefit from a robust research network and existing communication channels. Registered at Newcastle, the student will receive essential academic support, including regular supervisory meetings documented through the NU Reflect system and shared with the second supervisor. They will also benefit from Faculty and School training enhancing their research and transferable skills. To facilitate effective collaboration, **Dolfini will coordinate all communications with the partner organisation** (ISIS, a non-HE institution eligible under current NBC rules) **and broader supervisory team**. This will include six Zoom meetings each year with the two Newcastle supervisors and Scherillo from ISIS, ensuring consistent progress monitoring and fostering cross-disciplinary interaction. Clear goals and interim targets will be established and mapped onto a shared timeline, enabling continuous monitoring. **This comprehensive communication strategy will ensure effective risk management**, allowing for prompt responses to any challenges arising from scientific analysis and literature review (the latter is manageable in size but dispersed). This approach will guarantee timely project completion and the successful attainment of the research objectives.

What benefits will there be for the candidate and the non-HE partner organisation as a result of your collaboration?

(Maximum 200 words)

This project will provide the student with invaluable research experience and cutting-edge analytical skills, fostering an ability to bridge disciplinary boundaries. They will undertake a unique intellectual journey spanning the humanities,

social sciences, and materials sciences; reflect on the creation of scientific knowledge by reproducing the technologies that generate metallurgical data; acquire analytical and transferable skills sought by commercial and research employers; refine their data modelling and interpretation skills guided by world-leading specialists; and gain employability-enhancing practical experience at three state-of-the-art laboratories: the Archaeology NeMCAS facility, SAgE Analytical Services, and ISIS Neutron and Muon Source.

This project will also provide ISIS with a unique opportunity to address significant challenges in interpreting non-normative data from archaeological bronzes. Through the analysis of experimentally reproduced bronzes, ISIS scientists will **gain insights into the technical choices that create copper-alloy microstructures**, elevating their ability to interpret heritage science data. The latter point is highly significant, as the interpretation of analytical data is seldom validated experimentally. This situation has generated unquestioned orthodoxies, e.g., what crafting process created a certain microstructure. Refreshingly, this project provides a novel critical platform for interpreting neutron data and encourages **engagement with scientific, technological, and cultural heritage themes central to ISIS's mission**.

State what financial (if any) or in-kind contribution the non-HE partner organisation will be making over the duration of the award:

*(Maximum 200 words. A financial contribution is **not** a requirement. However, the AHRC expect that **non-HE partners based overseas** will make a financial contribution to the costs of the student's return travel and accommodation when visiting.)*

The partner organisation will grant sufficient personnel time to train the student in the techniques required by the project. Training will begin with **one-to-one sessions** with Scherillo to introduce ND and imaging techniques and instrumentation, followed by **self-study sessions**. The student will develop a deeper understanding of neutron scattering theory and neutron-matter interaction through attendance to **formal training courses** provided by ISIS (ISIS Practical Neutron Training Course) and partner institutes, including the Oxford Neutron School, the Central European Training School on neutron techniques, and the JCNS Laboratory Course.

- ISIS Practical Neutron Training Course: https://www.isis.stfc.ac.uk/Pages/ISIS-Neutron-Training-Course.aspx
- Oxford Neutron School: https://www.oxfordneutronschool.org/
- Central European Training School on neutron techniques: https://www.bnc.hu/cets/
- JCNS Laboratory Course: https://www.fz-juelich.de/jcns/EN/Expertise/ConferencesAndWorkshops/LabCourse/_node.html

Scherillo will also guide the student through the beamtime application process, ensuring a successful outcome. For each approved experiment, **ISIS will cover transport, accommodation, and subsistence costs for the student and their supervisor and up to £1500 in consumables**. This is a major financial contribution, considering that access to the facility has an allocated FEC value of about £20k per day, and **Scherillo's overall in-kind contribution to the project is estimated to be *c*.£32k**.

Describe the nature of the collaborative arrangement and the activities the candidate will be undertaking with the non-HE partner organisation:

(*Maximum 200 words*)

The student will be guided by Scherillo and colleagues during the experiment planning phase and beamtime application process. This approach fosters proactive project management, giving the student's high chances of success in their beamtime application. **Scherillo will also discuss training needs with the student**, **oversee all training** related to neutron techniques, and **provide one-to-one sessions** focused on software training and data analysis strategies using the software packages available at ISIS.

While at ISIS, the student will interact daily with scientists from diverse backgrounds who apply diffraction and imaging techniques to addressing similar challenges and research questions. They will be **encouraged to attend networking events and workshops**, such as the ISIS student conference and ISIS-Diamond Crystallography student days. Above and beyond all this, working at the ISIS Neutron and Muon Source is a **unique opportunity for a junior researcher to engage with a wide range of research approaches and analytical techniques**, providing career-enhancing insights and skills in multi-approach and multi-method materials analysis. The supervisory arrangements described below will ensure **effective risk management and seamless integration of neutron techniques into the project's broader research strategy**, ensuring timely completion and attainment of the research goals.

SECTION 3: SUPERVISION AND EXTERNAL ADVISORS	
Primary (or Co-) Supervisor:	Professor Andrea Dolfini
School or Department:	School of History, Classics and Archaeology
Email Address:	
Secondary (or Co-) Supervisor:	Dr Alasdair Charles
School or Department:	School of Engineering
Email Address:	
Advisor based at the Non-HE Partner Organisation:	Dr Antonella Scherillo
Organisation/Institution:	ISIS Neutron and Muon Source, Rutherford Appleton Laboratory, STFC, UKRI
Email Address:	
Advisor based at the Non-HE Partner Organisation:	
Organisation/Institution:	
Email Address:	
Additional Internal or External Advisors or Academic Supervisors, if any:	
Name:	Dr Christina Clarke
Organisation/Institution:	Australian National University
Email Address:	

Explain how the expertise of the supervisory team and external advisor(s) will allow them to support the proposed project and the selected candidate:
(Maximum 500 words)

The supervisory team and wider institutional network have been selected for their world-leading expertise and ability to provide with surgical precision to the student's training and professional development needs.

Prof Andrea Dolfini (lead supervisor, Newcastle) is a foremost specialist in prehistoric archaeology, copper-alloy technology, and the scientific analysis of ancient metalwork. He researches these subjects by originally combining social approaches, materials analysis, and experiments with past technologies and objects. He has authored 2 monographs, 2 edited volumes, and 60+ journal articles and book chapters on these subjects, mostly peer reviewed. He has been PI on 3 Horizon2020 and 1 HorizonEurope projects researching early metalwork and has attracted 5 NBC-funded and 1 NPIF-funded PhD students. He has supervised 1 MLitt and 7 PhD students to completion. He is the founder and lead convenor of MATCH, a Faculty Research Group providing interdisciplinary training, networking, and dissemination opportunities in material culture studies. https://www.ncl.ac.uk/hca/people/profile/andreadolfini.html

Dr Alasdair Charles (second supervisor, Newcastle) is an experienced corrosion engineer and academic lead for electron microscopy for the SAgE Faculty. He has worked on several cross-Faculty research projects during his career and has over 35 peer-reviewed papers published, along with conference proceedings, posters, and other outputs. He has extensive metallographic, microscopic, and analytical experience, which will support the project. He has supervised 14 PhD students to completion, including two archaeology students with Dolfini; he is currently co-supervising a PhD student investigating Roman bronze dodecahedra castings, with Duckworth and Dolfini.

https://www.ncl.ac.uk/engineering/staff/profile/alasdaircharles.html

Dr Antonella Scherillo (partner organisation advisor) is a beamline scientist working on the INES instrument for Neutron Diffraction and energy-selective imaging and elemental analysis. She has extensive expertise in the application of non-destructive techniques using neutrons for the investigation of archaeological objects. She leads the Heritage Science program at ISIS and chairs the panel for beamtime allocation to Heritage Science proposals. She has authored several peer-reviewed papers and book chapters centring on neutron and imaging techniques. She has co-supervised several MSc and PhD students and post-docs to completion and is now co-supervising two PhD students with the Cranfield Forensic Institute, the British Museum and Nottingham Trent University, and a post-doctoral research associate with the University of Milano-Bicocca, Italy. https://www.isis.stfc.ac.uk/Pages/Dr-Antonella-Scherillo.aspx

A bespoke network of external advisors will offer the student further training opportunities and research support. **Dr Christina Clarke** (ANU) is a leading academic and accomplished bronzesmith who researches prehistoric and historic metals through practice-centred approaches. She will provide advanced training in experimental bronzeworking during a yearlong Visiting Fellowship at Newcastle in student's Year 2. **Emeritus Professor Peter Northover** (formerly Oxford) is a recognised world authority in the scientific analysis of prehistoric metals. He will grant the student access to his collection of metallographic samples (thus circumventing sampling restrictions with archaeological objects) and provide expert guidance in metallographic data interpretation. **Dr Neil Wilkin** (Curator of Bronze Age collections, British Museum) will facilitate access to the collections under his care and advise the student on artefact loaning.

SECTION 4: RESEARCH ENVIRONMENT

Please provide details about the research environment the selected candidate will be joining and its suitability:
(Maximum 500 words)

The project benefits from the complementary research environments offered by Newcastle and ISIS. **The School of History, Classics and Archaeology (HCA)**, where Dolfini is based, has an internationally significant research portfolio in ancient technology, coordinated by the **MATCH Faculty Research Group** (https://research.ncl.ac.uk/match/). This group consists of 50+ research-active staff and c.15 PhD students, some of whom are also part of **EXARN, the School's PhD-led experimental archaeology network**. Several staff and postdocs working on ancient technologies, experimental archaeology, and archaeological science, including Conneller, Duckworth, Shillito, and Odler, contribute to this vibrant research environment. They teach **PGT modules that the student can audit** to acquire background knowledge or learn complementary analytical methods (e.g., ARA8392, Graduate Seminar in European Prehistory and ARA8025, Artefacts, teaching Metalwork Wear Analysis). The student will also engage in weekly seminars and reading groups organized by the School and MATCH, as well as PGR-coordinated initiatives like the Postgraduate Forum and annual conference. **Significant complementary expertise on early metallurgy and Bronze Age Europe and exists within the broader NBC consortium**, including Roberts (Durham) and Brandherm (QUB).

The **Advanced Materials Research Group in School of Engineering**, where Charles is based, hosts world-class facilities and expertise in materials analysis. The student will benefit from **considerable expertise in the microstructural analysis** of copper alloys and **unrestricted access to analytical equipment**. The group offers a vibrant research environment comprising 12 academic staff, 4 postdocs and 64 PGRs, fostering an active research culture through regular seminars and workshops, to which the student will contribute.

Newcastle boasts state-of-the-art analytical facilities essential for the project. The **Archaeology NeMCAS Facility** has recently been upgraded with a £876k investment by the AHRC Capability for Collections Fund. The microscopy suite includes a Leica M205C stereomicroscope, a bespoke Leica DM2700 MH metallographic microscope, and Keyence VHX 7000 digital microscope. The spectroscopy suite includes a Leica DM6 with integrated Laser-Induced Breakdown Spectroscopy and a portable XRF Bruker Tracer III-SD analyser for rapid compositional analysis. Additionally, the laboratory is equipped with two bronze casting furnaces and replicas of Bronze Age forging tools for experimental metalworking. The **Scanning Electron Microscopy Service, SAgE Analytical Services** includes two SEM machines with EDX microprobes, Vickers Hardness testers, a newly acquired EBSD analytical tool, and a collection of metallographic

samples for student training.
ISIS Neutron and Muon Source, located at the STFC Rutherford Appleton Laboratory in Didcot, is a world-leading centre for research in the physical and life sciences. **The suite of instruments available at ISIS provides unique insights into the properties of materials on the atomic scale, with a research focus on heritage science and archaeology**. The neutron diffraction and imaging instruments at ISIS are particularly suited for non-destructive measurement of archaeological and modern metals. The student will be integrated into an international research environment that offers world-class opportunities for specialist training (see above), professional networking across numerous museums and research institutes on four continents, and avenues for disseminating their research through internal workshops and international symposia.