Department of Archaeology, Conservation and History
Faculty of Humanities
University of Oslo

Publication trends and interdisciplinary collaboration across the archaeological science/humanities-divide:

Investigations into the epistemological structure of the archaeological discipline

An article-based dissertation for the degree of Philosophiae Master

Erlend Kirkeng Jørgensen
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1. Introduction

The archaeological discipline is diverse in most conceivable ways (Jones 2004:237). Diverse practice is observable in the institutional affiliation at different university departments, in the emphasis put on technologies, periods and methods, in theoretical orientations, in the financial structure of research and teaching, as well as in the national jurisdictions governing aspects of excavation and heritage management (Chapman 2008). At the epistemological level, archaeology is also divided in its relation to the sciences and humanities.

A founding premise of scientific practice, is the need for comparability between research results – in order to produce as solid and stringent knowledge as possible. For comparability to be achievable, the application of methods and theories have to correspond between individual projects. This provides incentives for the conduct of scientific disciplines to be consistent both internally and collectively. In this context, this raises the thesis´main point of interest: How might diverse practice affect the epistemological structure and comparability of archaeological research?

Epistemology is "the study of knowledge and justified belief" (Steup 2014), and is often described as the "theory of knowledge". I emphasize the latter, employing epistemology and the philosophy of science to asses knowledge production in archaeology. This implies a focus on the epistemological concepts of incommensurability, the two cultures-divide and academic fragmentation (to be explained below). In paper no.1 this is done by looking for the effect of diverse conduct upon the accumulation of knowledge and fragmentation in archaeology. In paper no.2 the abstract requirements of knowledge production is assessed in the interdisciplinarity collaboration between archaeology and archaeometry.

2. Paper summaries and results

This is an article-based master thesis consisting of two individual research papers. The purpose of this introductory text is to provide an overarching framework for the two papers (cf. Vaglum 2010:1632). Both papers correspond to a shared set of overarching aims:

1. To investigate the composition and state of archaeological epistemology, focusing on comparability and integration between sub-fields of the archaeological discipline.
2. To better understand the potential impact of the science/humanities-divide upon archaeological practice in publishing and applied epistemology in research strategies.

These aims are mostly examined separately in the two papers. When put together, the main ambition is to provide a deeper understanding of the relation between the structure and properties of archaeological epistemology, and diverse practice (within archaeology and in interdisciplinary cooperation) as influenced by the science/humanities-divide.

2.1. Summary of paper no. 1

Title: Measuring incommensurability: A bibliometric inquiry into what papers are presented in archaeological journals (2009-13), and the epistemic consequences

This paper presents the results of bibliometric analyzes conducted on a data set consisting of 926 archaeological papers. The data comprises all original research papers published in six top ranking archaeological journals in the period 2009-2013. The included journals are taken to represent different sub-fields in archaeology: Historical, anthropological, social, scientific, environmental and general archaeology. The aim is to map general features of archaeological publishing. Significant differences are identified amongst the journals on an array of parameters, covering journal statistics, citation network, thematic distribution, the application of methods and the direction of relevance to other sub-fields. Furthermore, the paper engages in an extended discussion over the epistemological consequences of the bibliometric results, focusing on disciplinary fragmentation, incommensurability, vagueness and the purported significance of the science/humanities-divide – pursued by the following problem statement:

> *1) What characterizes the archaeological research publishing in the six selected journals, in the period 2009-2013?*
> *2) What are the epistemological implications of diverse conduct amongst archaeological sub-fields, as evidenced by the publication trends of archaeology?*

2.1.1. Highlights of paper no.1

• Method: Bibliometrics is used to identify trends in archaeological publishing
• Data: 926 research papers from six top-ranking archaeological journals are subjected to quantitative analysis, covering all their published material in the period 2009-2013.
• Results: The correlation “the higher the rank of a journal, the more connected” is confirmed
• High amounts of discussion papers correlate with low amounts of archaeometric methods
• Significant differences on all codified parameters point to a sub-optimal division of labor
• Different affiliation to the science/humanities-divide affect archaeological publishing

2.2. Summary of paper no. 2

Title: Identifying key factors affecting the "two cultures"-relation of archaeology – Outlining a common epistemological platform for archaeology and archaeometry.

In relating to the debate over the nature of archaeology along the science/humanities-spectrum, this paper seeks to understand some *epistemological* challenges arising from integrating scientific methodologies with archaeology. The main objective is to evaluate what epistemological platform might integrate archaeology and archaeometry in interdisciplinary research projects, and how such a platform might provide productive interdisciplinary research strategies. Four epistemic factors at individual levels are examined, consisting of 1) communication, 2) specialization, 3) explanatory ideals and 4) uncertainty levels and types. A model of interdisciplinary research strategies is put forth in order to cope with these epistemic challenges. The opposing results of stable isotope analysis and faunal remains regarding diet during the Mesolithic/Neolithic-transition are presented as a case study, identifying general epistemological factors affecting the application of scientific methodologies in archaeology.

The overall question may not be given a proper answer within the confines of a paper. My humble contribution to archaeology is attempting to make clear the potential epistemological difficulties arising from interdisciplinary cooperation between archaeology and archaeometry (the application of scientific methods to archaeology):

> *1) What epistemological platform might integrate differing participants in interdisciplinary archaeological research?*
> *2) How can such a platform provide productive interdisciplinary research strategies for the combination of archaeology and archaeometry?*

2.2.1. Highlights of paper no.2

• Method: Epistemological analysis is used for investigating the relation between humanistically oriented archaeology and science-based archaeometry, with the aim of improving the understanding of interdisciplinary cooperation.

• Data: Four epistemological factors that might hinder integration between archaeology and archaeometry are examined: 1) communication, 2) specialization, 3) explanatory ideals and 4) uncertainty levels and types.

• Results: The integration of various specialists and methods is not just the synthesizing of various elements at the *end* of a cross-disciplinary research project, but just as important,

integration is an active mode of operation *during* research.
• Epistemic difficulties tend to accumulate in the research process if the most fundamental epistemic challenge is not resolved in advance of less fundamental ones.
• A common epistemic platform is postulated as a preferable solution to two cultures-dilemma in archaeology, in providing *research strategies* that ensures the highest possible level of relevance to all participants in interdisciplinary cooperation. Such may be achieved through a stepwise (bottom up) research strategy whereby the design of every research problem gets influenced by the mutual inclusion of field-specific topics.

The common epistemic platform presented in paper no. 2 is intended as a partial answer to the corresponding request made in paper no. 1. The papers are thereby directly related. More specifically; the first paper identifies and discuss what might be indicators of incompatibility due to lacking a common framework for evaluation and comparison of research results and the utilization of methods. The second paper tries to alleviate this situation by evaluating what properties of such a common framework are needed in order to secure fruitful interdisciplinary cooperation between archaeology and archaeometry.

3. Relevance

The main motivation driving the selection of topics for this thesis, is the sense of belonging to a time of great transformation in archaeology. As a student of archaeology during what (at present) seems to become termed as the "the third science revolution" (Kristiansen 2014) in future hindsight, I am intrigued by how the increasing application of natural scientific methods might affect archaeology´s analytic structure, as I do not think it is evident how archaeometry will put its mark upon archaeology in the long run. This also applies to interdisciplinarity in archaeology and the relation between other academic disciplines. Much literature has been devoted to debating our understanding of the archaeological discipline. Still, these debates have become slightly outdated in not taking fully into account the newly made possibilities provided by the increased precision and distribution of scientific methods in archaeology. Though teaching and reading has provided some insight into the relation between archaeology and the sciences, I was not fully satisfied with the attention given these topics and thus wanted to learn more. Most archaeologists probably have an opinion on matters such as "what is the landscape of archaeological publishing like" and "is there an opposition between humanistic and scientific trends in archaeology". Still, the lack of

empirical studies examining such questions may not provide a clear description of such topics. Thus, I want to make my own investigation. It is my hope that by applying bibliometric methods and epistemology to archaeology, I may contribute to making the fundamental structure of archaeology somewhat more comprehensible.

So how might the papers of this dissertation be of relevance to the wider archaeological discourse? Firstly, bibliometry is becoming increasingly important in all aspects of research and development, policy-making, academia and scientific management. In Norway, this situation is the result of the implementation in 2003 of the result-based redistribution-model for funding research and higher education, following the Reform on Quality in Higher Education.[1] This implied a restructuring of the Norwegian system of higher education to the international standardization of university programs – entailed in the Bologna process – such as the introduction of bachelor and master degrees, requirements on the progression of students, as well as a new system for funding research influenced by the bibliometric output of institutions (cf. NOU 2000:14). Being widely used for management purposes in the academic sector, bibliometric data is of interest to archaeology in providing a way to both map and study the wider landscape that archaeology is situated in. Being a quantitative and statistically based method, it allows for new research questions to be made that otherwise would be more difficult to study. Bibliometrics has seen few applications in archaeology, and present an untapped potential for empirically informed discussions over archaeology´s relation to other disciplines and internally amongst archaeological sub-fields.

Epistemology´s relevance to archaeology may arguably stem from it being *the study of knowledge*. As the very purpose of archaeology is producing knowledge of the past, epistemology is of intrinsic importance to the functioning of archaeology. Epistemology thus forms the founding structure on which all pursuit of archaeological knowledge must stand.

3.1. Internships

During the year of writing I was fortunate enough to be invited to Aarhus University, Denmark, to witness their implementation of interdisciplinarity in teaching and research. The stay also gave me valuable insights into the Danish academic system, providing background knowledge for my own work on bibliometrics and publication systems – amongst others by participating in the seminar on experiences made in the publication process: “Bring your

1 St. meld. 27; Orientering om forslag til statsbudsjett for universiteter og høyskoler; Rapportering av vitenskapelig publisering i helse-, institutt- og UH-sektor.

rejection letters. Reflecting on rejections and frustrations in the peer-review process".

As part of writing this thesis, I was granted a trip to the CAA Paris 2014 convention. It was useful for my insight into computational applications to archaeology, as well as providing some food for thought on the state of epistemic comparability in archaeology, which was to become the main topic of my work, and its relation to the technical-methodological state of archaeology (for a discussion of this connection see, McGlade 2014).

Digital and computational archaeology both facilitates and necessitates rigorous and unified practice, as informatics operates on rigid programming standards. Both fieldwork, documentation and distribution of archaeology has been hugely impacted by digital equipment making it easier to compare results across individual projects and compile national and international databases. In turn this provides hitherto unprecedented opportunities for grand synthesizing, replication and comparison across geographical and temporal divides (in GIS, statistics, simulation, Bayesian modeling of dating-sequences etc.). As this belongs to the practical and methodological domain of archaeology, I discuss them no further. Still, there are interesting implications of digital methods for archaeological comparability – what occurs to me as a vital but unrecognized contribution to the functioning of modern archaeology.

4. Background: The science/humanities-divide

There are many sides to the postulated divide between the sciences and humanities. As I discuss the history of the divide and its philosophical implications within the papers, I here wish to focus on its societal and economic aspects which provide some further background.

The very history of archaeology, starting of as antiquarianism, becoming increasingly systematic and institutionalized and today being part of the scientific corpus (Trigger 2006:81; cf. Baudou 2004), has seen multiple debates over the relation between the natural sciences and archaeology (i.e. Judson 1961; Tite 1970). I find that the debates result in some uncertainty as to the existence and relevance of the science/humanities-divide in archaeology. I therefore wish to present a case for its continued importance to the conduct of archaeology.

Natural scientific methods has been utilized for archaeological purposes from the very beginning, as reflected by the Køkkenmødding Commission (Madsen et al. 1900). Even so, the relationship has been subjected to trends beyond academia. I name two recent examples: First, the postmodern movement facilitated anti-realism and relativistic sentiments in the humanities (Sherratt 1993:125; (Trigger 1998:7, 2006:447; cf. Rorty 1999:96)). This was reflected by the breaking up of the processualist program in favor of a more existential and

hermeneutic approach to the past (e.g. Shanks and Tilley 1992; Tilley 1991). In practice, this resulted in a humanistic turn (often associated with the linguistic turn (i.e. Olsen 2006; Rorty 1992)), and less focus on the application of scientific methods in archaeology. Secondly, today the science/humanities-relationship in archaeology is much influenced by financial and political conditions facing higher education. The recent years have seen a restructuring of the humanistic sector of Europe and North America, following the financial crisis (Harpham 2011:16). In times of economic hardship, making the future seem uncertain, governments increase the pressure on students to study for degrees with pragmatic outcomes, while at the same time cut the funding for so-called unproductive disciplines (in technical terms). In Norway, there have been repeated debates over the usefulness of the humanistic disciplines, pinnacled by a report assessing the state of the humanities. Of special interest to us here, is that the report identifies "differing views on science" as one of the most important factors influencing the conditions for the humanities (Jordheim and Rem 2014:130). The trend of devaluing unproductive activities is not just an economic concern. Arguably it reflects as much a (more or less implicit) ideological stance towards the value of different disciplines, whereby the less tangible products of the humanities have been loosing to the applicability of scientific results during the last 200 years (Skouen 2014).

The topic of archaeology´s identity along the science/humanities-spectrum and its epistemological underpinnings has received some philosophical attention (Burdukiewicz 2006; Dark 1992; Krieger 2006; Schiffer 1981; Vernon 2014). Such investigations are likely motivated by archaeology´s intangible identity, at the same time being affiliated at historical, classical, religion, anthropological and scientific institutions around the globe. Thus archaeology arguably becomes one of the most multifaceted disciplines there is, and as a result, there are some concern over what would be the best conceptualization of archaeology.

A key matter determining the outcome on either side of the science/humanities-divide is the explanatory ambitions of archaeology. This influences what kind of questions archaeology may raise and what kind of answers are considered appropriate – in other words, affecting what it is to explain archaeological data and phenomenon. Though both sciences and the humanities aim at increasing the understanding of their data/phenomena, "understanding" as a means of description was directed to the social sciences and humanities, while the achievement of knowledge by means of causal explanation proper was reserved for the formal and natural sciences (cf. Weber 1949) - a division going back to the 1880s *Methodenstreit* of German academia (Brint 2002:212; Menger 1883; Schmoller 1883, 1884).

5. Methods

As different methods are applied to the specific papers, I have divided the methodological discussion regarding each paper into their own sections.

5.1. Bibliometrics

Paper no. 1 is a bibliometric analysis of archaeological publishing, providing quantitative measures of publishing in archaeology. *Bibliometrics* refer to a set of methods for quantitatively analyzing academic literature (De Bellis 2009:xi, 417), applying "mathematics and statistical methods to books and other media of communication" (Pritchard 1969:348; for a critical review of the method see (Archambault and Larivière 2009; Pendlebury 2009)). The common goal of bibliometric methods is to "investigate the formal properties of the scholarly publication system", and thereby making science itself the subject of inquiry (Bellis 2009:xi; for an excellent example see Fanelli and Glänzel 2013). Bibliometrics came into being during the 1920s but was not consolidated until the 1960s. Its development and dissemination has since evolved in accordance with the advances of information technology (Glänzel 2002; for the development and history of bibliometrics see Broadus 1987; Brookes 1990; Gross & Gross 1927; Lotka 1926; Nalimov & Mulchenko 1971; Price 1961; Price 1963; Ravichandra 1983). Although an established tool in informatics, mathematics, quantitative science studies and library science, bibliometrics has seen almost no application in archaeology (for exceptions see Mallía and Vidal 2009; Mays 2010). As such, there is an untapped potential in applying bibliometrics to archaeology.

In this paper I have utilized "JSTOR Data for Research","SJR's" SCOPUS-based database for Elsevier, "ISI Web of Science" and "Publish or Perish" for the collection of data. These analyzing tools where then applied to data sets coded in the database programs Access and Excel. The bibliometric analysis in paper no.1 may give the impression of representing academic publishing as a static, almost deterministic, process whereby there exist an agreement between every journal about their mutual division of labor. The publication process is of course an organic one, influenced by social, political and financial circumstances. This point is deliberately undercommunicated in the bibliometric analysis. First of all because the external factors influencing publication trends are beyond the scope of my research. Most importantly they are very difficult to actually measure and require a totally different set of methods and research questions. Secondly, it was a necessary action in order

for the analysis to provide meaningful results. The journals had to be viewed as self-containing entities, representing markedly different sub-fields within archaeology, an oversimplification resulting from the process of quantifying qualitative variables. As pointed out in the paper itself, I encourage a free criticism of my categorization and data selection. Still, I have tried to make the selection of data and its categorization to my best effort and think they should be informative of the actual state of publishing in parts of archaeology.

5.2. Epistemology as method

The epistemic focus of this thesis has major implications for the methodology. As I make an epistemological investigation into archaeology, my dissertation may most accurately be described as meta-archaeological, applying philosophy of science to archaeology (more on this in section 7 below). This approach includes three elements: 1) constructivity (not to be mistaken for constructivism), 2) comparative method, 3) evaluation of incommensurability.

From a methodological viewpoint, paper no.2 is a *constructive study*, in the sense of trying to answer constructive questions. Constructive research questions aim at establishing some actual conditions in the world, and furthermore also seek to improve these conditions (Kalleberg et al. 2009:52; Kalleberg 1996). The method is thereby constructive, in mapping epistemological factors affecting the outcome of interdisciplinarity between archaeology and archaeometry, with the aim of suggesting improvements through a common epistemic platform. The paper also applies a variation of the comparative method, as an assessment of commensurability essentially is comparative in nature: Two or more items are assessed against a common standard to determine their relation, in order to increase the comparability between elements (be it individual studies, application of a common method, a choice between contesting hypothesis etc).

6. Theory

As the individual papers present the necessary theoretical background, I here want to present an extended review of the theoretical concepts of importance to my thesis.

The underlying theoretical concept motivating both papers, is *incommensurability* – denoting the lack of a common standard, making elements incomparable/untranslatable (Kuhn 2012; Oberheim 2013). Although a concept with multiple origins (Duhem 1991; Feyerabend 1951, 1978:108; Oberheim and Hoyningen-Huene 2013), Thomas Kuhn put

"incommensurability" at center stage with the publication of *The Structure of Scientific Revolutions* [1962]. The concept has been applied to archaeology in trying to comprehend the shifts between schools of thought, and Kuhn´s concept of paradigm shifts has been most popular for this purpose (Trigger 2006:6). Rather than applying the paradigm concept, I transfer a similar problem focus to other domains of archaeology, examining potential incommensurability as a result of different takes on archaeology as part of the science/ humanities-spectrum, traceable through bibliometric methods and epistemological investigations into interdisciplinary collaboration with archaeometry. I consider it worthwhile to examine, as incommensurability may lead to suboptimal efficiency at the disciplinary level – potentially impeding archaeology´s ability to accumulate knowledge about the past[2].

7. Why meta-archaeology matters

The methodology and premises underpinning this thesis are unorthodox to archaeology. It might therefore be appropriate to provide a short apologetic for these unconventional choices. I here want to present what I take to be the four most compelling reasons for including the concerns of philosophy of science in the pursuit of a more complete and self-sufficient archaeological practice, in the form of four arguments.

Firstly, meta-archaeology is an established sub-field at the intersection between archaeology and philosophy, denoting "critical reflection upon the science of archaeology" (Embree 1992:3; Wylie 2001:617). Critical reflection upon archaeology has become a regular part of the analytic toolkit of archaeological research and practice, but the institutionalization of meta-archaeology as a topic of its own has been almost exclusively limited to North-America.[3] This is evident by the publication patterns of related topics, and by looking at the institutional affiliation of such authors. Without going into much detail, just looking at where courses in "the philosophy of archaeology" is part of teaching, and where the most significant authors are located (such as Alison Wylie, Washington – Merrilee Salmon, Pittsburgh – Lester Embree, Florida), gives a clue to the geographical aspect of where philosophy and archaeology may be viewed more or less as a natural combination. Of the archaeologists most

2 I uphold the value of diversity and critical discourse in facilitating efficient knowledge production in archaeology, as has been pointed out by Alison Wylie (1992; cf. Hodder 1999:160-1; Trigger 2006:515). I only refer to certain negative consequences of incommensurability, that might potentially become impeding.

3 It should be added to this that meta-reflections is hereby understood in the very specific sense of concerning the philosophy of science (of archaeology), while excluding the concerns of sociology of science – a distinction that, in my experience, often is obscured both in general and in archaeology (cf. Bunge 2012:173). European and Scandinavian archaeology has made vital contributions to the latter.

dedicated to issues in philosophy of archaeology, there is a strong correlation with processualism. Binford, Clarke, Schiffer, etc all made philosophy of science a vital part of their research designs. Binfords *Archaeology as Anthropology* (1962) may serve as an example of how issues from philosophy of science has been introduced in archaeology, in order to make clear the opposition between schools of thought. Such was the case in the transition from culture historical archaeology to processualism where philosophy of science was increasingly valued, as well as being of importance to the post-processualist movement – though in this case possibly assigned lesser value. The only major exception to this strong North American pattern, is Jean-Claude Gardin, a French archaeologist who made vital contributions to meta-reflections in archaeology, though more to the semiotics of a universal framework for interpretation of archaeological materials (Ammons 2014:2953; for contributions made by Gardin see 1958, 1980, 1989a, 1989b). The point is: There is a lopsidedness in the geographical distribution of meta-archaeological reflections, centering on the north-American continent, that merit adjustment.

Secondly, I find the history of archaeology indicating that a strict separation between the practical conduct of archaeology and the meta-reflections concerning best practice, does not provide ideal conditions for the further progress of the discipline (as by "naïve empiricist" claims that data speak for itself, see (Darvill 2008; Johnson 2011:775; Witmore 2015)). It is therefore important that ground level archaeological conduct and higher order self-reflection connect, in order for the two parties to inform each other. Claims of "ivory tower theorizing" and "mindless empiricism" may only be rectified by a stronger integration between all parts of archaeology, e.g. by making both field and meta-archaeologists accountable to each others research. I thus hold that meta-reflections should not be outsourced to specialists *outside* archaeology, but instead need to partake in constructive knowledge exchange. If we are to avoid the loss of vital experiences made by empiricist archaeologists, meta-archaeological reflections cannot by handed over to external forces. Instead, archaeology might benefit from taking on what could seem like tedious problems of philosophy (Johnson 2010:3–5; Jones 2004:329; Jørgensen 2015), but which I claim is for the betterment of archaeological practice.

Third, meta-archaeology plays an especially important role in contributing to the successfulness of interdisciplinary collaboration between archaeology and other fields of study. This is because (as hopefully will become evident by this thesis) the integration between disciplines of different origin, specific terminologies, explanatory models, and scientific ambitions, is not something to take lightly. Making the best of such cooperation

requires an understanding of the concepts and premises of the participating discipline, and is precisely what meta-reflections can provide. In the case of archaeology drawing upon supporting sciences in studying the past, considerations of how to make such cooperation as fruitful as possible, are to be understood as meta-archaeology. Such is already practiced (i.e. in excavation reports see, Gjerpe 2008; 2013), but a collective focus is lacking. I therefore claim that meta-archaeology still has a part to play in the further development of archaeology.

Finally, meta-archaeology helps archaeology make better arguments (Smith 2015:2; cf. Bunge 1996:111, 2012:3; Trigger 1998). By elucidating the analytic structure of theoretical constructs and by dissecting the components of archaeological explanations, meta-archaeology may help archaeology in general become more stringent. Making sure the communication between archaeologists are as efficient and transparent as possible, is important to the functioning of the discipline. This is all the more important the more diverse the cooperating participants are – either when specialists in different sub-fields of archaeology are to cooperate, or between specialists across disciplinary boundaries in interdisciplinary research groups (a point made in paper no. 2).

8. Concluding remarks

In concluding this introductory chapter, I wish to make a point of much importance. Some readers may hold the sentiment that my project do not relate strongly enough to archaeological data (in the traditional "artifact-based" sense) or to established debates in archaeology. To this I wish to say the following: After reviewing all recent literature on the philosophy and epistemology of archaeology, I came to find that the contributions are often unlinked to each other, without connections to a general debate on such issues, and limited to being a small part of papers focusing on other matters. Thus, there is no well established global debate on the epistemology of archaeology. Still, I do not see this as an argument for leaving the issue to itself. In my opinion, it rather goes to show the need for such a debate, and thereby reflects the relevance of my project. I sincerely hope the preceding thoughts on meta-archaeology and the motivation driving this thesis is convincing enough to allow this to pass as bold and fully fledged archaeology. I would like to thank anyone taking the time to read this thesis, hopefully finding the results and discussions herein informative.

The following two papers are intended to build on each other: Paper no. 1 provides a general backdrop of, and poses some questions to be examined in paper no. 2. Even though they are independent, I would recommend that the papers are read in the given order.

References

Ammons, Michelle
2014 Gardin, Jean-Claude. In *Encyclopedia of Global Archaeology*, edited by Claire Smith, pp. 2952–2953. Springer New York.

Archambault, Éric, and Vincent Larivière
2009 History of the journal impact factor: Contingencies and consequences. *Scientometrics* 79(3): 635–649.

Baudou, Evert
2004 *Den nordiska arkeologin - historia och tolkningar*. Kungl. Vitterhetsakademien, Stockholm, June 24.

Bellis, Nicola De
2009 *Bibliometrics and Citation Analysis: From the Science Citation Index to Cybermetrics*. The Scarecrow Press, Inc., Lanham, Md.

Brint, Steven G.
2002 *The Future of the City of Intellect: The Changing American University*. Stanford University Press.

Broadus, R. N.
1987 Toward a definition of "bibliometrics." *Scientometrics* 12(5-6): 373–379.

Brookes, B. C.
1990 Biblio-, sciento-, infor-metrics??? What are we talking about. In *Informetrics*, edited by L. Egghe and R. Rousseau, pp. 31–43.

Bunge, Mario
1996 *Finding Philosophy in Social Science*. Yale University Press, New Haven, Conn.,
2012 *The Sociology-Philosophy Connection*. Reprint edition. Transaction Publishers, New Brunswick.

Burdukiewicz, J, M.
2006 Epistemological status of archaeology - current controversies. *Archaeologia Polona. Special theme: Archaeology – anthropology – history. Parallel tracks and divergences*. Vol. 44. Pages: 73-88.

Chapman, Robert
2008 Alternative States. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 144–165. Springer New York.

Dark, Ken
1992 The Science of Archaeology. *Philosophy Now* 3: 21–22.

Darvill, Timothy
2008 Empiricism. *The Concise Oxford Dictionary of Archaeology*. Oxford University Press, Oxford.

Duhem, Pierre Maurice Marie
1991 *The Aim and Structure of Physical Theory*. Trans. Philip P. Wiener. Reprint edition. Princeton University Press, Princeton, July 29.

Embree, Lester
1992 The Future and Past of Metaarchaeology. In *Metaarchaeology*, edited by Lester Embree, pp. 3–50. Boston Studies in the Philosophy of Science 147. Springer Netherlands.

Fanelli, Daniele, and Wolfgang Glänzel
2013 Bibliometric Evidence for a Hierarchy of the Sciences. *PLoS ONE* 8(6): e66938.

Feyerabend, Paul

1951 *Zur Theorie der Basissätze (phd. dissertation)*. P. Feyerabend, Universität Wien.
1978 *Science in a Free Society*. Verso, London, January 1.

Gardin, J. C.

1958 Four codes for the description of artefacts: an essay in archeological technique and theory. American Anthropologist 60: 335-57.

1980 Archaeological constructs: an aspect of theoretical archaeology. London: Cambridge University Press.

1989a Artificial intelligence and the future of semiotics: an archaeological perspective. Semiotica 77: 5-26.

1989b The role of "local knowledge" in archaeological interpretation, in S. J. Shennan (ed.) Archaeological approaches to cultural identity: 110-22. London: Routledge.

Gibbon, G.
1984 *Anthropological Archaeology*. Columbia University Press, New York.

Gjerpe, L. E. (red.)
2013 *Oppsummering og arkeometriske analyser. E18-prosjektet Gulli-Langåker Bind 3*. Fagbokforlaget.
2008 E18-prosjektet Vestfold - Bind 4 - Kulturhistoriske, metodiske og administrative erfaringer. Bind 4. Varia 74

Glänzel, Wolfgang
2002 A Concise Introduction to Bibliometrics & its History.

Gross, P. L. K., and E. M. Gross
1927 College Libraries and Chemical Education. *Science* 66(1713): 385–389.

Harpham, Geoffrey Galt
2011 *The Humanities and the Dream of America*. University of Chicago Press, Chicago.

Johnson, Matthew H.
2010 *Archaeological Theory: An Introduction*. 2 edition. Wiley-Blackwell, Chichester, West Sussex, UK ; Malden, MA, January 19.
2011 On the nature of empiricism in archaeology: On the nature of empiricism in archaeology. *Journal of the Royal Anthropological Institute* 17(4): 764–787.

Jones, A.
2004 Archaeometry and materiality: materials-based analysis in theory and practice*. *Archaeometry* 46(3): 327–338.

Jordheim, Helge, and Tore Rem (editors).
2014 Rapport om de humanistiske fagenes situasjon i Norge: Hva skal vi med humaniora? Fritt Ord.

Judson, Sheldon
1961 Perspectives: Archaeology and the natural sciences. *American Scientist* 49(3): 410–414.

Jørgensen, E. K.
2015 Fetisjering i arkeologiske forklaringer. Primitive Tider. Pp. 35-50.

Kalleberg, Ragnvald
1996 Forskningsopplegget og samfunnsforskningens dobbeltdialog. I: Holter, Harriet og Kalleberg, Ragnvald: *Kvalitative metoder i samfunnsforskning*. Universitetsforlaget, Oslo.

Kalleberg, R., Malnes, R., & Engelstad, F.

2009 Samfunnsvitenskapenes oppgaver, arbeidsmåter og grunnlagsproblemer. Særtrykk av kpittel 4-8 i Introduksjon til samfunnsfag. Vitenskapsteori, argumentasjon og faghistorie [2005]. Gyldendal Akademisk, Oslo.

Krieger, William Harvey
2006 *Can There be a Philosophy of Archaeology?: Processual Archaeology and the Philosophy of Science*. Lexington Books.

Kristiansen, Kristian
2014 Towards a new paradigm? The Third Science Revolution and its Possible Consequences in Archaeology. Current Swedish Archaeology, Vol 22, 2014. Pp. 11-34.

Kuhn, Thomas S.
2012 *The Structure of Scientific Revolutions: 50th Anniversary Edition*. Fourth Edition edition. University Of Chicago Press, Chicago ; London.

Lotka, Alfred J.
1926 The frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences* 16(12): 317–324.

Madsen, A.P., S. Müller, C. Neergaard, C.G.J. Petersen, E. Rostrup, K.J.V. Steenstrup & H. Winge
1900 *Affaldsdynger fra Stenalderen i Danmark Undersogte for Nationalmuseet*. Copenhagen: C.A.Reitzel.

Mallía, Ma Soledad, and Aixa Solange Vidal
2009 From the Opposite Corner: A Bibliometric Analysis of Research on American Archaeology in European Publications. *Archaeologies* 5(3): 446–467.

Mays, S.
2010 Human osteoarchaeology in the UK 2001–2007: a bibliometric perspective. *International Journal of Osteoarchaeology* 20(2): 192–204.

McGlade, James
2014 Simulation as Narrative: Contingency, Dialogics, and the Modeling Conundrum. *Journal of Archaeological Method and Theory* 21(2): 288–305.

Menger, C.
1883 *Untersuchungen über die Methode der Socialwissenschaften und der politischen Ökonomie insbesondere*

Nalimov, V. V., and B. M. Mulchenko
1971 *Measurement of science: Study of the development of science as an information process*. Foregin Technology Division, Washington, DC.

NOU 2000:14
2000 Frihet med ansvar — Om høgre utdanning og forskning i Norge. Kirke-, utdannings- og forskningsdepartementet, Oslo

Oberheim, Eric, and Paul Hoyningen-Huene
2013 The Incommensurability of Scientific Theories. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta. Spring 2013.

Olsen, Bjørnar
2006 Scenes from a Troubled Engagement: Post-Structuralism and Material Culture Studies. In *Handbook of Material Culture*, pp. 85–103. SAGE Publications Ltd, 1, London.

Orientering om forslag til statsbudsjett for universiteter og høyskoler
2014 Kunnskapsdepartementet, Oslo. Accessible at:

https://www.regjeringen.no/nb/tema/utdanning/hoyere-utdanning/Statsbudsjettet/orientering-om-forslag-til-statsbudsjett-for-universiteter-og-hoyskoler/id619675/

Palomar, T., M.Y García-Heras, and M.A. Villegas
2009 Archaeological and historical glasses: A bibliometric study. *Boletin de la Sociedad Española de Articulo Cerámica y Vidrio* 48(4): 187–194.

Pendlebury, D. A.
2009 The use and misuse of journal metrics and other citation indicators. *Archivum Immunologiae et Therapiae Experimentalis*, 57:1-11.

Price, D. de Solla
1961 *Science since Babylon*. Yale University Press, New Haven.
1963 *Little Science, Big Science*. Columbia University Press, New York.

Pritchard, Alan
1969 Statistical bibliography or bibliometrics. *Journal of Documentation* 25(4).

Rapportering av vitenskapelig publisering i helse-, institutt- og UH-sektor
2014 Accessible at: http://www.cristin.no/cristin/rapportering/rapporteringsinstruks.html

Ravichandra, Rao I. K.
1983 *Quantitative methods for library and information science*. Wiley Eastern, New Delhi.

Rorty, Richard M.
1992 *The Linguistic Turn: Essays in Philosophical Method*. Reprint edition. Rorty, Richard M. (ed.). University Of Chicago Press, Chicago, March 1.
1999 *Achieving Our Country : Leftist Thought in Twentieth-Century America*. Harvard University Press, Cambridge, Mass., September 1.

Schiffer, Michael B.
1981 Some Issues in the Philosophy of Archaeology. *American Antiquity* 46(4): 899–908.

Schmoller. G. V.
1883 Zur Methodologie der Staats- und Sozialwissenschaften" in *Jahrbuch für Gesetzgebung, Verwaltung und Volkswirtschaft im deutschen Reich.*
1884 Irrthümer des Historismus in der deutschen Nationalökonomie

Shanks, Michael, and Christopher Y. Tilley
1992 *Re-constructing Archaeology: Theory and Practice*. Psychology Press.

Sherratt, Andrew
1993 The relativity of theory. In *Archaeological theory: who sets the agenda?*, pp. 119–130. New Directions in Archaeology. Cambridge University Press.

Skouen, Tina
2014 Den store omdømmekampen. *Aftenposten*.

Smith, E. Michael
2015 How can archaeologists make better arguments? *Unpublished manuscript*. Accessible at: https://www.academia.edu/9925096/_How_can_archaeologists_make_better_arguments_n.d._

St.meld. nr. 27 (2000-2001). Gjør din plikt - Krev din rett. Kirke-, utdannings- og forskningsdepartementet, Oslo.

Steup, Matthias
2014 Epistemology. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta

Tilley, Christopher (editor).
1991 *Reading Material Culture: Structuralism, Hermeneutics and Post-Structuralism*. 1 edition. Wiley-Blackwell, Oxford, January 16.

Tite, M. S.
1970 The impact of the natural sciences on archaeology. *Contemporary Physics* 11(6): 523–539.

Trigger, Bruce G.
1998 Archaeology and Epistemology: Dialoguing across the Darwinian Chasm. *American Journal of Archaeology* 102(1): 1.
2006 *A History of Archaeological Thought*. 2 edition. Cambridge University Press, Cambridge England; New York.

Vaglum, P.
2010 Doktoravhandlingens sammenstilling – hva skal den inneholde? *Tidsskrift for Den norske legeforening* 130:1632-4

Vernon, Kenneth Blake
2014 Philosophy of Archaeology. *1000-Word Philosophy*.

Weber, Max
1949 *On the methodology of the social sciences*. Glencoe, Ill. : Free Press.

Witmore, Christopher
2015 Archaeology and the Second Empiricism. *Debating Archaeological Empiricism: The Ambiguity of Material Evidence*: 37–67.

Paper 1

Measuring incommensurability: A bibliometric inquiry into what papers are presented in archaeological journals (2009-13), and the epistemological consequences.

Abstract: This paper presents the results of bibliometric analyzes conducted on all original research papers published in six high ranking archaeological journals between 2009-2013, resulting in 926 papers. Significant differences are identified amongst the journals on an array of parameters, including journal statistics, citation network, thematic distribution, the application of methods and the direction of relevance to other sub-fields. The results are put to further use in an extended discussion over their epistemological consequences, focusing on disciplinary fragmentation, incommensurability, vagueness and the purported significance of the science/humanities-divide in archaeology.

Introduction

The aim of this paper is to quantitatively examine differences in archaeological publishing, and the effects upon archaeological epistemology. More specifically, I intend to evaluate the epistemic effects of diverse practice upon the accumulation of archaeological knowledge, assessing the state of *commensurability* and *fragmentation* on a disciplinary scale.

As point of departure I propose that for claims of new knowledge to be accumulative, they must share some basic epistemic structure with the established knowledge base – thereby making them *commensurable*. The core idea of commensurability simply implies the need for a common standard if two elements (i.e. research results) are to be directly comparable (Merriam-Webster 2015a). Without a common standard, comparisons are prone to "incomplete" translations resulting in a loss of information and hence comparability. This is of importance to archaeology as diverse practice may produce varying research outputs, making the comparability and integration between sub-fields harder. Through the analyzes of sub-disciplinary journals, by way of bibliometric methods, this paper poses the following research questions:

> *1) What characterizes the archaeological research publishing in the six selected journals, in the period 2009-2013?*
> *2) What are the epistemological implications of diverse conduct amongst archaeological sub-fields, as evidenced by the publication trends of archaeology?*

In trying to answer these questions the paper applies a set of bibliometric methods in the analysis of what research are presented in a selection of archaeological journals. The analyzes focus on established correlations regarding the connectedness of high-ranking journals, the

relation between types of papers and methods used, and how different affiliations to the science/humanities-divide affect archaeological publishing. Being a set of methods to quantitatively analyze academic literature (Bellis 2009:xi,417), *bibliometrics* allow the processing of large data sets, in this case consisting of all research papers published in six high ranking archaeological journals, in the period of 2009-2013, comprising 926 papers.[1]

While bibliometric evidence can be quite informative in it self, this paper applies such quantitative measures in an effort to elucidate certain epistemological qualities of the archaeological discipline. Following the bibliometric analysis of trends in archaeological publishing, the main issue is assessing the specific epistemic quality of "commensurability" in archaeology. Ultimately, such investigations allow us to inquire whether archaeology is being constructively specialized, or undergoing fragmentation, resulting in an inefficient "division of labor" between its constituent sub-fields. Before getting to the analysis, I present some theoretical concerns affecting the analysis.

Research status

Theoretical diversification has been the hallmark of archaeology since the 1990s (Bintliff and Pearce 2011:5; Fahlander 2012:122–123); Hodder 2012; Kristiansen 2014:15; Trigger 1998;15, 2006:484,497; Webmoor 2007a:568). Contemplating the contemporary status of archaeology, one might further add the diversification of archaeological conduct in general – illustrated by the ever expanding panoply of archaeological journals. There is as well a shared perception of archaeology as being a multifaceted discipline (Jones 2004:327), operating at the intersection between historical and social sciences, applying methods corresponding to the whole range of natural sciences to the aesthetics. Such diversity also includes the application of theory. Though social and anthropological theory has received most attention, natural scientific theorizing is of fundamental importance to questions of dating, site formation, taphonomy, ecology, climate etc. (Martinón-Torres and Killick 2015). Archaeological diversity is furthermore mirrored by the various ways in which the discipline has been institutionalized around the globe. By a rough typology, archaeology has been the smaller sister of history in Northern Europe (Trigger 2006:164), as part of the anthropological project in North America (cf. Binford 1962; Trigger 2006:410), and as one of many humanistic

1 The included parameters of the bibliometric analysis is a result of the selected journal data and time period. The historical dimension is undoubtedly important to the formation of the journal characteristics such analysis aim at describing, but is beyond the scope of this paper.

disciplines within classical studies (Whitley 2001:3), especially for the Mediterranean region. The unequal weighting of the empirical record and prioritization of prehistoric periods, has led archaeologists to internalize a variety of academic identities, as a response to a multitude of educational and institutional affiliations (a point made early on by Polanyi (1958:151)).

The prominence of these differences are debated (Killick and Young 1997). No matter their importance, today such differences are played out on a different arena and scale – namely in the world of academic publishing, to which we will return. Still, what I take to be the most profound element of archaeological diversity is the different epistemologies underpinning archaeological research (Trigger 1998:1).

Epistemology and diverse practice

Epistemology concerns ways of knowing, posing questions regarding how we can, may and do know what we know, assessing the justification for this acclaimed knowledge base (Steup 2014). In archaeology and science in general, adopting multiple ways of knowing should be a positive, as multiplying the ways of doing research will result in a broadened knowledge acquisition? Though intuitively convincing, the answer is not so straightforward as hopefully will become clear.

Multiplying the ways of doing archaeology has been endorsed by the concepts of *pluralism* and *multivocality*. The concepts of pluralism/multivocality has been the stepping stone into meta-reflections for many archaeologists, and the diversification of archaeological epistemology has become a standard narrative when summarizing the leave from processualism to post-processualism (Trigger 1998:15). In mentioning these terms I wish to clarify their difference to the concepts of incommensurability and fragmentation. No critique is meant of the ethics of multivocality (Atalay 2008; Habu et al. 2008; Hodder 2000, 2004, 2005, 2008; Kim 2008; cf. Webmoor 2007b) or of the value of plurality (for contribution to such topics, including public archaeology, see Fahlander 2012; Habu and Fawcett 2008; Harlow 2011; Jameson 2014; Wylie 1999, 2008).

Crucially, the conceptual pairs of pluralism/multivocality and fragmentation/ incommensurability address different problems as they belong to different levels: The first concerns ethical and practical conduct while the second is strictly epistemological.[2] In this paper, I argue that the epistemological concepts may provide fruitful insights, adding to the

2 The actual counterpart in the epistemological debate belongs to constructivism, relativism and anti-realism. Even though pluralism/multivocality often corresponds with a relativistic and anti-realistic epistemology, the connections are seldom made explicit, thereby confusing the different levels at which epistemology and ethics operate (for a critique of this divide see Fricker 2009).

ethical and practical ones that are possibly more familiar to archaeology.

Pluralism and multivocality responds to some very real consequences of archaeology, taking seriously the ethical and social implications of archaeological conduct. As such, they have been important in highlighting the extra-scientific responsibility of archaeology, to the point of now being an integral part of international practice.[3] Even so, there are some epistemological implications of the two concepts that are of concern. The challenge posed by these terms arise from their explicit endorsement of multiple (and opposing) epistemologies.

Pluralism (the diversification of interpretation by subjecting the archaeological record to a range of opposing views) has widespread acceptance in archaeology, as the inherent uncertainties of the empirical record makes alternative interpretations a constant possibility (Darvill 2008a). Although sharing some structural similarities to hypothesis testing, pluralism also entails a broadened definition of the who´s and what´s that are of relevance to archaeological interpretation. As such, the aim of plurality is to "encourage the development of different pasts, new and valid pasts, new truths, to pose questions, to examine doubt and uncertainty" (Shanks and Tilley 1992:258). As such, pluralism promotes an archaeology that is open to the outside community, encouraging the interplay between experts and lay people (Blakey 2008:20).

Multivocality (the active integration of diverging narratives, which mostly contains the relativistic rejection of any objective measure for evaluating the multivocal narratives (Darvill 2008a; Hodder 2000) takes it a step further in claiming that interpretation to a large extent (how large is debated) is the result of non-academic factors, positing that social, political, gender and economic factors fundamentally affect scientific practice and output. Multivocality entails an ethical component and a social engagement in trying to provide the disadvantaged a saying in history (Hodder 2008:196; Wylie and Lynott 1995). Furthermore it exists to counteract grand narratives, opposing the unified aim of western science (and earlier, European colonialism) (Silberman 2008).

When claiming that pluralism and multivocality are different to epistemological concerns in belonging to separate levels of abstraction, one may wonder why these concepts needs clarifying. All sciences and other intellectual pursuits take the accumulation of

3 Most archaeological and anthropological associations now have a set of ethical principles to abide by. To name a few: the World Archaeological Congress Ethical Statement (First Code of Ethics, The Vermillion Accord on Human Remains), The American Anthropological Association Statement on Professional Responsibility and Ethics, European Association of Archaeologists (1997 EAA Code of Practice, 1998 EAA Principles of Conduct), Canadian Archaeological Association (1999 Statement Of Principles For Ethical Conduct Pertaining To Aboriginal Peoples) etc.

knowledge over time as a point of departure. Without accumulation there can be no specialized knowledge, and thereby no substantial growth to human knowledge. But actual accumulation is not just the adding of one piece of knowledge to the rest of what is know. For claims of new knowledge to be accumulative, they must share some basic epistemic structure with the established knowledge base – thereby making them *commensurable*. As the concept was introduced to philosophy science during the 1960s, it assumed the function of evaluating the pros and cons in a choice between opposing theories (cf. Oberheim and Hoyningen-Huene 2013): If two sets of statements cover the same empirical data but supports different conclusions, how are we to choose between them and evaluate which one is more correct? For there to be any proper choice, the opposing elements must be commensurable. And if commensurability is to be achieved, the process by which the results were produced must be translatable. Such similarity is usually ensured by standardized methods and the institutionalization of disciplines. The concepts of pluralism and multivocality seem to go against such common procedures, including multiple epistemologies in archaeological knowledge production. As a result, employing opposing epistemologies within the same discipline may lead to *fragmentation*, which describes the underdevelopment of connections between the sub-fields of a discipline. This is of importance to the subsequent analysis, as progressed fragmentation is the precondition for any eventual incommensurability in archaeology.

One thing must be settled at this point: As a fundamental premise I take fragmentation and incommensurability to present an unfortunate and undesirable condition for any academic discipline to be in. The reason for claiming this is the lack of any consensus on the matter, to the point where the opposite view has been endorsed – directly promoting fragmentation and the diversification of archaeological epistemology (e.g. Gero 2007) – multivocality and pluralism acting in support of such diversification. When in this paper, "epistemic qualities" are discussed, it simply refers to the epistemological properties that characterizes archaeology. If several (and opposing) epistemological stances are thought to be compatible within archaeology at the same time, as by the advocates of pluralism/ multivocality, this poses a challenge to commensurability. If this challenge is thought to be substantial or just an analytic construction, again depends on ones epistemological reliance.

Claims of synthesis has also been forwarded, and has mainly come from two camps, 1) in the postulation of evolutionary theory as a unified scientific framework (Fog 2009; Gers 2011; Mesoudi 2011; Mesoudi et al. 2006; Lyman and O'Brien 1998; O'Brien et al. 1998;

Riede et al. 2012) and 2) from the strand of philosophy of science evaluating archaeology (Bell 1994; Binford 1962, 1981:28, 2001; Clarke 1978, 1979; Dunnell 1971, 1989; Embree 1992; Gardin 1980; Salmon 1982:140; Schiffer 1976; Schiffer 1996; Watson 1986; Watson et al. 1971).What separates the two directions (pluralizing or unifying archaeological epistemology), seems to correspond well with the much debated science/humanities-divide: The proponents of multivocality and pluralism adhering to humanistic ideals in archaeology, and the proponents of a unified archaeology presenting a scientific outlook on archaeology (something I will return to in the discussion).[4]

These statements might seem like a reactionary academic policy, representing a return to positivism and scientism, all together neglecting the progress made by diversifying archaeology (cf. Bintliff 2011:8). This is not my intention. The proponents of multivocality and pluralism are likely as attuned to the aim of learning as much as possible about the past, as any other archaeologist. If so, it entails an implicit acceptance of the need for accumulation, commensurability and the avoidance of fragmentation.

In turning to the actual analysis, we begin by presenting the methodology.

Method

Bibliometrics is essentially a set of methods to quantitatively analyze academic literature (De Bellis 2009:xi, 417). This is done by applying "mathematics and statistical methods to books and other media of communication" (Pritchard 1969:348). The most common and well-known application of bibliometrics is through the analysis of citations, their frequencies, patterns and relation to other variables (see Rubin 2010; Garfield 1983) – a method widely used for ranking journals, institutions and scholars on impact-indexes. Though consisting of a number of methods, the common goal of bibliometrics is to "investigate the formal properties of the scholarly publication system", and thereby making science itself the subject of inquiry (Bellis 2009:xi; for an excellent example see Fanelli and Glänzel 2013). Bibliometrics originated during the 1920s but was not consolidated until the 1960s. Its development and dissemination has since evolved in accordance with the advances of information technology (Glänzel 2002; for the development and history of bibliometrics see Broadus 1987; Brookes 1990; Gross & Gross 1927; Lotka 1926; Nalimov & Mulchenko 1971; Price 1961; Price 1963; Ravichandra 1983). Today bibliometrics constitutes its own field of study, mainly

4 Some attempts at synthesis has also been proposed through the application of pragmatism to archaeology (Bergsvik 2001; Mrozowski 2012; Silva and Baert 2013), though without receiving much attention yet.

directed at methodological development, providing numeric and evaluative input to science, as well as to policy making, grant- and application management.

Although an established tool in informatics, mathematics, quantitative science studies and library science, bibliometrics has seen almost no application in archaeology (for exceptions see Mallía and Vidal 2009; Mays 2010; Palomar et al. 2009). Most archaeologists come in contact with bibliometrics when choosing which journal to submit a paper to based on metrics such as impact factor, or through administrative tasks during their carrier, writing applications and managing faculty statistics. As such, there is an untapped potential in applying bibliometrics to archaeology.

Some points must be made to the relevance of bibliometrics in identifying the extent of incommensurability and disciplinary fragmentation. One might ask how a bibliometric analysis can contribute to archaeology in ways not provided by the more commonly used qualitative methods such as discourse-, content- and textual analysis. There may be several answers to such objections: Firstly, the sheer quantity of data that can be included in bibliometric analysis present other possibilities, e.g. if interested in larger phenomena. Secondly, a different range of subjects are available for study through the use of bibliometrics, e.g. the frequency, distribution and spread of concepts, methods and citations contra interpreting meaning and disclosing power struggles in texts. Thirdly, bibliometrics allow different answers to questions that may also be examined by other means. Whereas discourse analysis tend to reduce its subject matter to the factors external to argument and language, bibliometrics aims for a very different goal in trying to map the internal correlation between variables. For example, both might be interested in the structure and semantics of academic publishing, the discourse analyst focusing on relations between text and meta-textual factors, the bibliometric analyst focusing on the numerical impact of a text on the general research community through the study of its citation network.

Though often posed against one another, qualitative and quantitative methods must be seen as fundamentally complementary. As this paper will hopefully show: We are better positioned to know something about archaeology´s epistemic qualities by combining both methods. Archaeological epistemology being the main interest of this paper, it must be stated that the method at hand does not provide sufficient means for evaluating research results (cf. Glänzel 2002). Instead I claim that bibliometrics provide an empirical and analytic platform on which epistemological discussions otherwise in lack of empirical evidence may stand.

Material

In limiting the scope of this paper the bibliometric analysis consist of the following selection of data, chosen on the basis of its representativeness, thereby enabling the identification of general features in archaeological publishing. The data set consists of 926 papers, covering the five year period of 2009-13. The most recent data is not included due to not presenting reliable information. The specified time slot is of interest both in presenting recent data, in covering the marked upswing of publishing during this period (compared to preceding years), bibliometric studies existing only prior to this period and since some of the included journals came into being just in advance.

The journals selected are assumed to represent various sub-fields, in the hope of securing some representativity on behalf of the variety within archaeological publishing. After building a database over all the papers, it is then subjected to a number of bibliometric analyzes. The main purpose is to investigate what kind of topics are being examined in each individual paper. In addition some parameters has been codified per paper, allowing further investigation of the distribution and application of methods as well as citation networks.

This paper exclusively presents data from regular journals. That is, journals with less than 15 papers per issue, and 2-4 issues a year, published on paper (in contrast to online and open source publishing). Given these criteria, some of the biggest and top rated journals have been omitted. These being digital, with a much higher number of papers per issue and with up to four times the number of issues per year. When mapping trends in archaeological publishing, this is an unfortunate but necessary measure taken to control the volume of data. Only original research-papers are included, thereby excluding editorials, reviews, discussions, book reviews, erratums and otherwise non-original studies. The main directive for selecting journals is their ability to be representative of archaeological sub-fields, in this case historical, anthropological, social, scientific, environmental and general archaeology. The statements of purpose presented by the respective journals will influence the results presented below, and are hence reviewed:

- *Antiquity (A):* “a quarterly review of World Archaeology interested in all research questions, in all periods and all parts of the world”.
- *Archaeological and Anthropological Sciences (AAS):* “covers the full spectrum of natural scientific methods with an emphasis on the archaeological contexts and the

questions being studied. It bridges the gap between archaeologists and natural scientists providing a forum to encourage the continued integration of scientific methodologies in archaeological research".

- *Journal of Anthropological Archaeology (JAA):* "devoted to the development of theory and, in a broad sense, methodology for the systematic and rigorous understanding of the organization, operation, and evolution of human societies".
- *Journal of Social Archaeology (JSA):* "promotes interdisciplinary research, focused on social approaches in archaeology, it champions innovative social interpretations of the past and encourages exploration of contemporary politics and heritage issues".
- *Environmental Archaeology (EA):* "consider the interaction between humans and their environment in the archaeological and historical past".
- *International Journal of Historical Archaeology (IJHA):* "focuses on the post-1492 period and includes studies reaching into the Late Medieval period ... [and] present the latest theoretical, methodological, and site-specific research".

One could just as well have included journals representing classical, heritage, computational, evolutionary or any other archaeological sub-field. It is only for the sake of feasibility that such has been omitted. Though taken to represent some general attributes of archaeological publishing, the data reflect (some might say suffer) from a geographic dislocation as only journals based in Britain and America are included. Specifically three American and three British journals, in the sense of being published in the given region. Even so, the most important criteria for selection has been the journals representativeness for a given sub-specialty. As the selection is based on topic instead of geographical affiliation, no region specific journals are included. The lack of geographical diverse journals should not be impairing as the included journals publish research from all over the world, and are all within the high-to-top ranking amongst specialized *archaeological* journals. Table (1) summarizes the quantity of papers and metrics of the journals included in this study.

The information value of such metrics (as presented in table 1) are somewhat disputed. They are anyhow listed here to provide the reader a basic overview of the included journals. The dispute concerns whether such metrics present a fruitful way of evaluating the output of scientific research. The critical voices claim that particularly the impact factor (originally a device for helping libraries select the most important journals for their collections), does not function properly as an indicator of the importance of individual

papers, but rather represent a mix-up of a scientist´s reputation with the ranking of a journal (cf. The San Francisco Declaration on Research Assessment; Batista et al. 2006; Penfield et al. 2014; explicating the connections to open access publishing see Norris et al. 2008; Solomon et al. 2013).

Table 1. Summarized metrics for the journals included in the bibliometric analyzes. The differing values presented under cites, average cites (AM) per paper and max cites correspond to the values provided by Web of Science above and Publish or Perish below, in brackets (). The h5- index and- median are procured from Google Scholars ranking metrics, while the 5-year impact factor is provided by the journals themselves. The SJR is Scopus´ take on the impact factor, calculated using the same algorithm, but over a shorter time span.

*The h5-median of JSA, and the 5-year impact factor for IJHA could not be obtained. I have calculated an estimated value for the latter, using a scatter plot and best-fit-to-curve function, which seems reasonable when correcting it with a ration of 2:3 between SJR and the 5-year impact factor. This value is therefore unofficial, and has been included in order to give the reader a relative sense of the journal´s impact factor in order to make comparison easier.

Journal	Papers (n)	Cites	*AM* cites, Pr paper	% of n With 0 cites	Max cites, Total amount of years	h5-index	h5-median	SJR	5 year Impact factor
Journal of Social Archaeology	82	241 (550)	3,05 (6,11)	44,46%	23 (65)	7	-	0,688	1
Journal of Anthropological Archaeology	181	1044 (1680)	5,77 (8,65)	17,79%	29 (43)	19	25	1,333	2,453
International Journal of Historical Archaeology	164	186 (399)	1,15 (2,33)	68,19%	12 (22)	8	10	0,264	(0,44)* -
Archaeological and Anthropological Sciences	112	492 (913)	4,47 (5,67)	43,65%	52 (73)	14	25	0,649	1,06
Environmental archaeology	70	182 (357)	2,53 (2,36)	49,39%	16 (16)	9	14	0,588	0,974
Antiquity	317	1421 (2554)	4,41 (8,05)	46,13%	53 (76)	21	29	0,873	1,43

Source critical factors

It has been necessary to quantify *qualitative* variables, as there are no existing database which contains the data needed for this study. A problem connected to this line of work is the unfortunate result of having to catalog each paper manually. Looking at already quantified parameters would enable the use of preexisting, bibliometric analyzers such as *Web of Science*, *Publish or Perish* and *Scopus*. These ready-made bibliometric programs allow for direct statistical queries of a given data set. Even so, there are problems related to the interpretation of such queries, if used uncritically. In this instance, it would be possible (but misleading) to catalog a paper under a given subject, based only on the occurrence of a corresponding word in either the paper´s title, abstract or the whole document. Instead it is necessary to evaluate each paper individually, so as to identify the main purpose of research.

The thematic data of the 926 papers was collected directly from the online homepage of each journal and then plotted into an Excel sheet. Citation data and journal metrics (the

analyzes of which are presented in table 1) was collected using two sources: *Web of Science* (WoS) and *Publish or Perish* (PoP). The metrics was then calculated manually, so as to correct the values provided by the WoS and PoP databases. It was necessary to combine and correct the two manually, as they provide quite diverging results. WoS produces overly conservative estimates, while the opposite is true for PoP. In short, the reason for this is unequal access to appropriate databases and different ways of calculating the metrics. At the time of writing, a whole range of journals are not included in the WoS catalog. PoP on the other hand, collects data from Google Scholar. This provides some pros and cons for the analysis presented below, that needs mentioning: PoP provides a much wider array of sources for citation analysis, by collecting data from both journals, books, internet journals and other digitized (or otherwise online registered) media, in all languages. The downside is the inclusion of "unofficial" cites, such as non-peer reviewed blog entries. The numbers presented in table 1, must therefore be given a critical reading, and this is why I have listed the metrics collected from both WoS and PoP. Notwithstanding my best effort to avoid unreliable data, there will undoubtedly still be a certain margin of error in the numbers presented here. Anyhow, the extent of such errors should not be much, as such erroneous cites constitute a very small fraction of the data set (in the range of ≤1 %).

Timing is another important factor that needs mentioning as metrics are dynamic values. The metrics presented here are but a snapshot of archaeological publishing and discourse, representing the very period the data was collected. Also, no age-weighted metrics are included, as the aim of this analysis is to compare results *within* the given time frame (2009-2013).

Classification: Thematic categories

After building a database of information per paper, the thematic consideration of each paper was classified into a manageable number of categories, thereby reducing the vast variation of topics. The classification was made with some initial categories thought to be prevalent in the data set. Over time, the growing number of categories was integrated in the further description of papers, before a full correction of the data set was made, employing the entire set of categories to the complete database. I have tried to comply with the guidelines provided by the international classification of academic literature used in libraries, and used the classification provided by the *EBSCO Anthropology Plus* for calibration. Table 2 illustrates the analytic scheme applied in the analyzes.

Table 2. The 29 thematic categories employed in the bibliometric analysis.

Class 1: Phenomena	Class 2: Environment	Class 3: Meta
Art/Symbolism	Agriculture/Husbandry	Conceptual
Civilization/Culture History	Dating/Age/Chronology	Heritage
Class/Inequality	Diet/Subsistence	Method
Colonialism/Indigenous	Ecology/Climate	Research History/Critique
Cosmology/Identity/Ritual	Evolution	Theory/Interpretation
Death/Burial	Formation/Taphonomy/Preservation	
Economy/Exchange/Production	Health	
Gender	Human impact	
Infrastructure/Monuments	Hunter-gatherers	
Population/Mobility	Provenience	
Power/Politics/Conflict	Settlement/Land use	
Technology/Function	Zooarch/Animal	

The thematic categories have been divided into two levels, a primary level and a secondary level. The primary level consists of three major groups of categorical classes, each containing a number of second-level categories. *Phenomena* includes categories of the most recurring research on past phenomena. The class represents themes researched in "immediate" archaeology, that is, papers presenting new findings on the assorted topic. *Meta* on the other hand, encompasses those papers somehow reflecting on archaeology itself, either through the development of new methods and theories, or through critique. *Environmental* refers to categories that in some way are external to culture processes, being more or less extra-somatic (Binford 1965:205; White 1959:8). Though also presenting "immediate" results on past phenomena (thereby overlapping with *Phenomena*), these categories are oriented towards the interplay between culture and nature/habitat/landscape.

Representing a more fine grained classification of the data, the secondary level consists of a total of 29 categories. The division between the two levels has a dual function: Firstly, it provides *analytic* clarity. Secondly it helps counteract any subjective bias that might affect the classification itself, as there may occur significant overlap between the categories. It thereby secures the correct weighting of variables in the analysis presented below, as any incorrect classification on the secondary level should be counteracted by the classification on the primary level. The allocation of categorical membership has been made according to a set of rules:

- Categorization is based on a combination of the information provided by title, abstract and keywords. If difficult to ascribe a category, introduction and conclusion are read. If still unclear, a skimming of the main text is done. The reason for not basing the analysis entirely on the keywords provided by the authors themselves, is the need to compress the thematic variation to a manageable number. Heavy emphasis has still

been put on the keywords providing vital information regarding the main topic of the papers.

- Papers are categorized by the area of knowledge the papers aim at.
- If a paper incorporates elements attributed to two distinct categories (according to the above scheme), the paper will be assigned to the category most dominantly present.
- Papers on contemporary issues concerning archaeology and society, such as power, politics and policy, will be classified as *Heritage*, not *Power/Politics*), as the latter is reserved for papers focusing on power and politics as a prehistoric phenomenon.
- *Antiquity* has its own specific section on "method". These papers are also included here, and are classified as *Method*.

It is possible to question the categorizations made herein by emphasizing other aspects. This is an unavoidable weakness in quantifying what is essentially qualitative variables. Although there are some risk of categorical overlap and errors of codification on my part, the two-leveled classification should counteract possible incorrect categorizing. This is because the chance of misplacing a paper decreases with the widened scope of classificatory classes. The primary level provides such a broad class, and is also most telling of the bigger picture.

Results

Table 3 shows the full data range of thematic distribution. Only highlights relevant to the further analysis will be further discussed.

Table 3. Metrics for the distribution of primary and secondary category levels.

	Journal of Social Archaeology		Journal of Anthropological Archaeology		International Journal of Historical Archaeology		Archaeological and Anthropological Sciences		Environmental Archaeology		Antiquity	
	%	n	%	n	%	n	%	n	%	n	%	n
Class 1: Phenomena Total	40,24%%	33	51,93%	93	57,24%	94	25,00%	28	7,14	5	48,89%	155
Art/Symbolism	2,43%	2	1,10%	2	0,60%	1	3,57%	4	1,42%	1	8,20%	26
Civilization/Culture history	-	-	-	-	-		-	-	-		4,73%	15
Class/Inequality	-	-	0,55%	1	15,24%	25	-	-	-	-	-	-
Colonialism/Indigenous	6,09%	5	1,10%	2	12,19%	20	-	-	-	-	0,94%	3
Cosmology/Identity/Ritual	20,73%	17	3,31%	6	8,53%	14	0,89%	1	1,42%	1	4,10%	13
Death/Burial	2,43%	2	3,86%	7	6,09%	10	2,67%	3	-	-	6,30%	20
Economy/Exchange/Production	-	-	4,41%	8	5,48%	9	-	-	-	-	5,04%	16
Gender	1,21%	1	0,55%	1	0,60%	1	-	-	-	-	-	-
Infrastructure/Monuments	-	-	1,10%	2	-	-	-	-	-	-	3,78%	12
Population/Mobility	-	-	8,28%	15	1,21%	2	3,57%	4	1,42%	1	4,41%	14
Power/Politics/Conflict	4,87%	4	12,70%	23	3,65%	6	-	-	-	-	3,15%	10
Technology/Function	2,43%	2	14,36%	26	3,65%	6	14,28%	16	2,85%	2	8,20%	26
Class 2: Environment Total	0,00%	0	40,33%	73	10,97%	18	49,10%	55	78.57%	55	24,92%	79
Agriculture/Husbandry	-	-	4,97%	9	-	-	8,92%	10	21,42%	15	5,67%	18
Dating/Age/Chronology	-	-	-	-	-	-	4,46%	5	2,85%	2	9,46%	30
Diet/Subsistence	-	-	6,62%	12	1,21%	2	10,17%	12	11,42%	8	1,26%	4
Ecology/Climate (environ recon)	-	-	3,86%	7	-	-	2,67%	3	10,00%	7	-	-
Evolution	-	-	2,76%	5	-	-	0,89%	1	-	-	1,57%	5
Formation/Taphonomy/Preserve	-	-	1,10%	2	0,60%	1	5,35%	6	2,85%	2	-	-
Health	-	-	1,10%	2	0,60%	1	-	-	-	-	-	-
Human impact	-	-	-	-	-	-	0,89%	1	5,71%	4	-	-
Hunter-gatherers	-	-	6,07%	11	-	-	-	-	-	-	1,26%	4
Provenience	-	-	-	-	-	-	9,82%	11	-	-	-	-
Settlement/Land use	-	-	12,70%	23	8,53%	14	2,67%	3	12,85%	9	5,04%	16
Zooarch/Animal	-	-	1,10%	2	-	-	2,67%	3	11,42%	8	0,63%	2
Class 3: Meta Total	59,76%	49	8,28%	15	31,70%	52	25,89%	29	14,28%	10	26,18%	83
Conceptual	6,09%	5	1,10%	2	7,31%	12	-	-	-	-	0,31%	1
Heritage	15,85%	13	-	-	10,36%	17	-	-	-	-	0,31%	1
Method	6,09%	5	6,07%	11	5,48%	9	23,21%	26	11,42%	8	20,18%	64
Research history/Critique	8,53%	7	-	-	3,65%	6	-	-	1,42%	1	1,26%	4
Theory/Interpretation	23,17%	19	1,10%	2	5,48%	8	2,67%	3	1,42%	1	4,10%	13
Total:	*100,00%*	*82*	*100,00%*	*181*	*100,00%*	*164*	*100,00%*	*112*	*100,00%*	*70*	*100,00%*	*317*

Thematic distribution

The journals publish papers very much in accordance with their stated purpose. An example of this is *EA´*s almost exclusive appearance under the (first-level) class *Environment*, by nearly 80 %. *JSA* provides the direct opposite, 0 % of its papers falling under the

environmental class. Instead, it has the highest values for the *Meta*-class (60 %), and *JSA´s* most numerous themes are *Theory/Interpretation* = 23,1 7%, *Cosmology/Identity/Ritual* = 20,73 % and *Heritage* = 15,86 %

Method constitutes *AAS´*s most prominent theme, which amounts to 23,21 % of its papers. *Antiquity* also presents a high amount of papers belonging to *Method*, = 20,18 % of its total. Even so, there are significant differences in the qualitative aspects of the papers concerning method in these two journals. Whereas *AAS* presents papers on the technical development and improvement on scientific methods, *A* mainly presents the immediate application of scientific methods in archaeology.

Antiquity stands out with a general culture-historical profile. Interestingly, the papers ascribed to the category *Civilization/Culture history* exclusively belongs to Antiquity and, even more specific, they mainly represent studies conducted in China. Does this point at a diverging practice amongst archaeologists publishing in Antiquity? It might be one of the very few actual markers of incommensurability, as the rest of the community seems to produce research not so clearly directed at culture-historical archaeology. What causes this is not clear. It might point at some national differences and the continued relevance of methodological nationalism, or more interestingly, an effect of the need for basic research in an otherwise under-explored area –what earlier was also the case for the Indus valley. This pattern is also supported by Antiquity being alone in presenting papers on *Infrastructure/Monuments*, in the sense of describing roads, ditches, earthworks, standing monuments etc in themselves.

Methods used

Table 4. Bibliometric data for the methods used in the 926 papers.

	Social	Historical	Antiquity	Anthropological	Environmental	Sciences
Physical archaeometry	-	-	11,35%	3,31%	5,71%	50,89%
Bioarchaeology	-	3,00%	9,46%	27,61%	75,71%	25,00%
Computer modeling	-	1,83%	2,52%	11,60%	-	0,89%
Excavation/Survey	2,43%	8,00%	14,82%	10,49%	-	1,78%
Material study	11,00%	16,46%	10,00%	18,23%	1,43%	-
Discussion/Theoretical	79,26%	65,00%	38,00%	22,65%	5,73%	11,60%
Experimental	-	-	2,83%	0,55%	8,57%	1,78%
Other	-	5,00%	10,41%	5,52%	2,85%	9,00%

How the research presented in the papers have been conducted might be as informative as the thematic distribution. A marker for this parameter is signified by [Method used], classified per paper. This might indicate the most significant difference between the journals, as there seems to be clear cut and distinctive boundaries between them. As shown by (table 4) and

(figure 1), the number of theoretical and discussion papers almost forms a perfect fall off-curve, corresponding to a descending number of archaeometric methods –an inversely proportional relation.

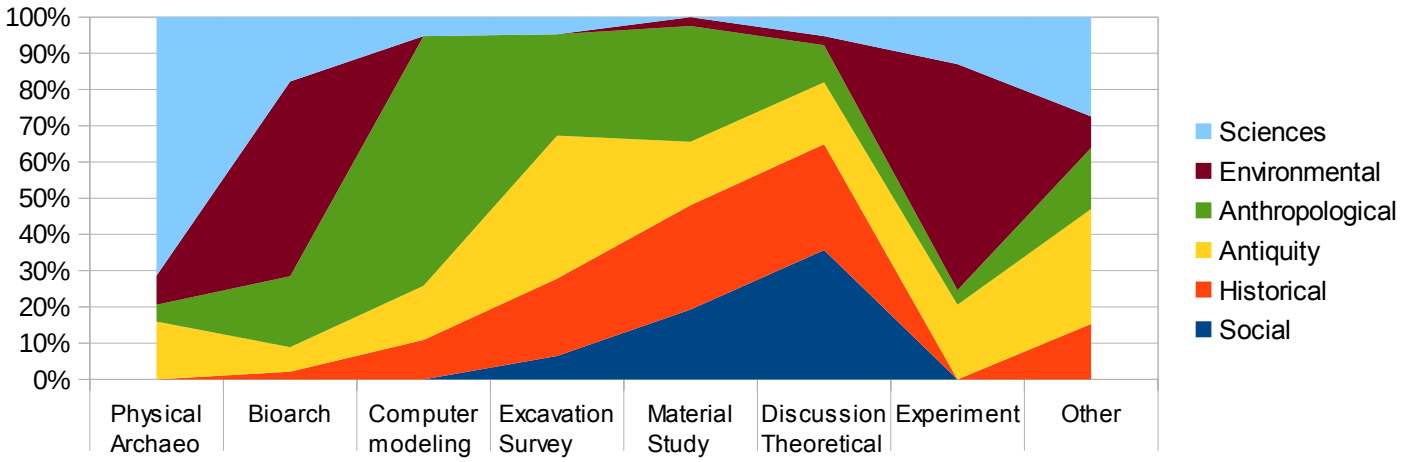


Figure 1. Graphical representation of table 4, in a "stacked percentage" diagram.

It is interesting to note that this pattern quite resembles the hierarchy of sciences (Fanelli & Glänzel 2013). This is evident from the "concentric" pyramid-like shapes in figure 1, the first corresponding to the methods used by *JSA*, restricted to the methods of the lower half of table 4. Next, *IJHA* has a somewhat bigger scope, while *A* and *JAA* utilize the whole range of methods (included in this typology). The latter two are the most comprehensive and highest ranked journals in this analysis, which is also reflected in the broader scope of interests and methods used.

Citation analysis: Cross-references

It is possible to map the connections between variables at both the level of papers and the level of journals. This can be done by identifying the patterns of citing amongst papers and between journals, thus allowing the citation-network to be studied. As shown in table 1, and graphically reproduced in figure 2 and 3 below, there are large differences in both the number of papers, number of cites per paper and the percentage of papers with zero cites amongst the six journals included.

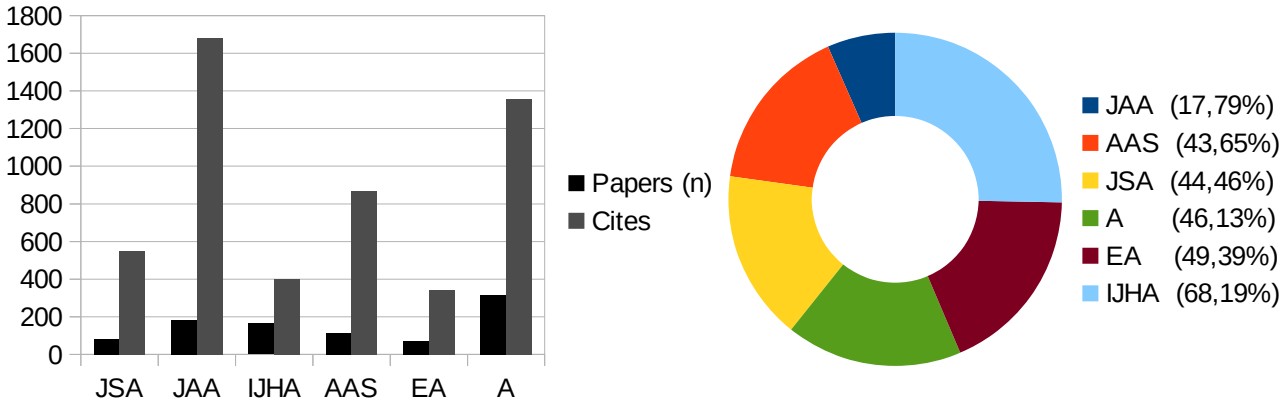


Figure 2 and 3. Left: Relation between number of papers and number of cites. Total numbers. Right: Percent (%) of selection (n = 926) which has been cited zero times during the present period. The values for this particular diagram was collected from SJR, covering only 2009-2012, as no reliable data was otherwise available.

Reviewing the percentage of cites coming from the other journals within the given time frame, may indicate to what extent citation occurs across sub-disciplinary units. As illustrated by table 5, there are no large differences in the sum of cross-references, that is, cites coming from the other journals included here. The one exception is *IJHA*, which has less than half of its cites coming from the five other journals. This is probably due to its multidisciplinary profile, producing a citation-network overlapping with historical journals. Once again *JAA* and *A* stand out, in this case with high degrees of self-citing. There are several potential explanations for this, but it might be attributed to the all-round function of these journals (as witnessed by their broad scoped statement of purpose – cf. Section 3.1), providing a lively community for debate and (more importantly here as only original research-papers are included), the foundation for cumulative progress.

Table 5. The extent of cross-referencing between the included journals. Highest external cites (blue), and self-cites (red). These numbers should be reliable, as the WoS databases include all the journals analyzed in this paper. As such, the number of cites amongst the respective six journals should therefore amount to the actual coverage made up of cross-citation (given in %).

Social	Times cited	% of n (82)	Environmental	Times cited	% of n (70)	Antiqiuty	Times cited	% of n (317)
Antiqiuty	2	2,43%	Antiqiuty	1	1,42%	Antiqiuty (self)	92	29,00%
Environ.	0	0,00%	Environ.(self)	11	15,71%	Environ.	6	1,89%
Historical	7	8,53%	Historical	1	1,42%	Historical	4	1,26%
Anthro arc	3	3,65%	Anthro arc	4	5,71%	Anthro arc	25	7,88%
Social (self)	15	18,29%	Social	0	0,00%	Social	5	1,57%
Sciences	0	0,00%	Sciences	3	4,28%	Sciences	13	4,10%
Sum total		*33,00%*	*Sum total*		*28,50%*	*Sum total*		*45,70%*
Sum of others		*14,61%*	*Sum of others*		*12,83%*	*Sum of others*		*16,70%*

Historical	Times cited	% of n (164)	Anthro. Arc.	Times cited	% of n (181)	A. A. Sciences	Times cited	% of n (112)
Antiqiuty	2	1,21%	Antiqiuty	16	8,83%	Antiqiuty	10	8,92%
Environ.	0	0,00%	Environ.	1	0,55%	Environ.	2	1,78%
Historical (self)	16	9,75%	Historical	1	0,55%	Historical	1	0,89%
Anthro arc	0	0,00%	Anthro arc (self)	50	27,62%	Anthro arc	6	5,35%
Social	7	4,26%	Social	4	2,20%	Social	0	0,00%
Sciences	1	0,60%	Sciences	6	3,30%	Sciences (self)	17	15,17%
Sum total		*16,00%*	*Sum total*		*43,00%*	*Sum total*		*32,00%*
Sum of others		*6,07%*	*Sum of others*		*15,43%*	*Sum of others*		*16,94%*

When the results in *table 5* are transformed into graphical expressions of the citation-network, some points of interest appear (see figure 4). Depending on the given confidence interval, more or less of the network becomes visible. Even though the interval of >4 % is not too significant, the bar could be raised to 8 % and a simplified (less connected) version of the center cluster would still remain, thereby being the most stable and significant network.

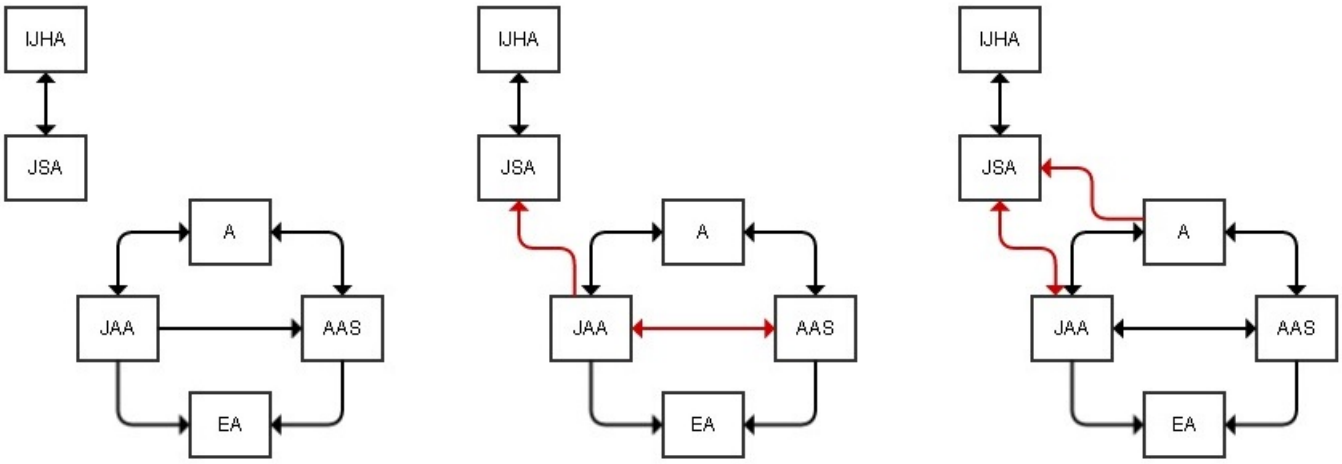


Figure 4. Citation-networks according to the confidence interval of >4 % (left), >3 % (middle) and >2 % (right). The direction of arrows denotes the directionality of citing. Double headed arrows indicate cross-referencing, according to the given confidence interval. Red arrows mark new nodes in the network compared to the former interval.

As illustrated by the figure, the journals form connections of different kinds depending on what confidence interval (percentage of cites explained by a journal *X*) is applied. What is most profound is the center cluster, as it prevails different levels of testing – which underpins the representativeness of the observable patterns (at least for *JAA-A-AAS*). I find it reasonable to assume the center cluster to represent some vital part of the actual center cluster that would arise if all relevant journals were included. In such a case, the secondary cluster which forms the upper left corner of this diagram, would be supplemented by the completion of the other corners. Some common denominators for the center cluster (together with those already listed) are Journals of Archaeological Science, Archaeometry, World Archaeology, Current Anthropology – in short, the journals with the highest ranking. This means that proximity to the center (in terms of cross-referencing), seems to correspond to the ranking of journals. Thus, the higher the rank of a journal, the more connected (through citations). This is a confirmed correlation (described by Bradford´s law and Zipf´s law), though subjected to a recent weakening whereby highly cited research no longer is reserved for a handful of top journals (Lozano et al. 2012; Larivière et al. 2014; cf. Weale et al. 2004).

Discussion of results

What might be expected of the results if they were to indicate an optimal and efficient division of labor within archaeology? First of all, a very low number of papers would be left without making some contribution to the professional discourse, by way of not receiving any cites. Secondly, there would be a high degree of cross-referencing between journals. As the division of labor functions smoothly, one sub-field would build on the work being done in other sub-fields, evident by an extensive citing between sub-disciplinary journals. As a result, all parts of the citation-network would be interconnected, and the degree of integration would increase with thematic proximity. Thirdly, the thematic distribution should take the form of overlapping normal distributions or stepped pyramids, so that when placing the results next to each other, there should be a falling curve from that of highest relevance, descending to the next journal where the topic is quite relevant, until the journal where the topic is not relevant. This line of relevance would be reversed by other journals. Fourthly, there would be a substantial overlap between journals in what methods are being used. Looking beyond the various content listed in the journals´ statement of purpose, they all have in common some ambition of explaining/interpreting the past. The main differences should not be in the utilization of methods, but in how they are put to use (corresponding to the journal-specific focus on periodic or geographical area). Notwithstanding, the results point to some deviation from this idealized condition.

Zero-cites

The number of papers that have received zero cites in this time period, ranges between 17,79-68,19 %, with an average of 44,94 %. This seems to be normal for the highest ranked archaeological journals (checking with Scopus). This supports the centrality of these journals in the citaion-network described above, as the highest ranked journals also tend to receive the most cites. Still, almost half of the papers presented are not cited at all. A large review showed that levels of zero-cites correspond to different branches of science, placing these results closer to the social (32 %) and natural sciences (27 %), than the humanities (82 %), for this parameter (Larivière et al. 2009). A spectrum appears when dissecting the results: Whereas *JAA* has very few zero-cites (17,19 % - close to the ultimate low of 12 % set by medical journals, thus falling way below the average for natural science journals), *IJHA* stands out with a particularly high amount (68,19 %), closer to the humanistic average.

The rate of zero-cites must be kept in mind when reviewing a journal´s impact factor,

as it is based on the average number of cites per paper, not the median. Therefore, a journal with a high percentage of zero-cites and some highly cited papers, can give the impression of sufficient citing all over. In this very case, about half of the papers have not been cited, which affects their impact factor/SJR as presented in table 1. When coupled with the values for zero-cites, there is a strong inverse correlation with the impact factor, making high ranking correspond with low amount of zero-cites. This is confirmed by the highest ranked journal *JAA*, having the lowest percentage of zero-cites. Conversely the lowest ranked journal *IJHA*, has the highest percentage of zero-cites.

Cross-references

Figure 4 provides a modest illustration of what we may call *the direction of relevance*. It describes the general direction most of the cites are oriented towards – that is, in what journals papers (from the original set) are considered relevant. When checking for external citing (cites coming from journals not included here) *JSA* predominately gets cited by anthropological journals, but also some heritage and literary reviews. *IJHA*, naturally gets cited by other historical and contemporary archaeology journals to a high degree, but also social matters such as by slave, theater and art reviews. Both diverge from the other four, in being more specifically oriented towards humanistic journals. A massive study on citing amongst specifically humanistic journals has identified archaeology as highly connected to classics and religion-studies, and secondarily to history (Leydesdorff et al. 2011:2420–1).

The situation is a bit different when it comes to *EA*, *JAA* and *AAS*, as they all have in common being directed towards scientific journals such as Archaeometry and Journal of Archaeological Science. A large bulk of all their cites comes from these two, together with journals of physical, chemical and biological science. Internally, both *JAA* and *AAS* cite *EA*. The relation does not work the other way around, *EA* turning out as a link towards the environmental sciences. Being a specialist journal, these factors put together may explain *EA* ´s low rate of cites (both absolute and amongst the included journals) and modest metrics (cf. Table 1) and ranking (SJR). In sum, there are weak connections between the two clusters (as shown in figure 4), and some one-way connections amongst the archaeometric journals.

Another factor that seems to influence the distribution of cites is geography, as the main bulk of cites given to a specific journal comes from the corresponding country as the cited journal. As such, the majority of American journals´ citation-network stems from other American journals. The same pattern goes for British journals.

It might seem unfair comparing such recent cites as of the previous five years, due to the distribution of cites being time dependent. One might therefore claim that journals exhibit unequal "output profiles", e.g. accumulating cites at different rates. Some journals receive a steady number of cites between year x and y, while others might have a decreasing or increasing output profile over time. If so, a journal with an increasing output profile will be underrepresented in this analysis due to the lack of time to accumulate cites. Even so, different output profiles pose no challenge to this paper. Rather opposite, differences in the time it takes to manifest the direction of relevance to other journals, only go to demonstrate the different characteristics of the journals.

Thematic distribution

The thematic distribution exhibits large differences (cf. Table 2). *JAA* and *A* seems most all-round with a general coverage of most categories, with main emphasis on past phenomena. *EA* and *AAS* clearly discriminate against the [Environment]-class, while *JSA* and *IJHA* are the only journals with significant emphasis on [Meta]-class (when not counting technical, methodological development).

Some topics come out as exclusive to particular journals. Even though this may follow naturally from the journals representing specialized sub-fields within archaeology (such as *EA´*s correspondence with environmental topics), it is still noteworthy that some topics that by no means are necessarily bound up with the program statements of a specific journal, only occur in some journals, and not others. For instance, a singular treatment of topics arises from *IJHA´*s take on *Class/Inequality* = 15,24 % and *Colonialism/Indigenous* = 12,19 %. Though occurring in *JSA*, there seems to be no apparent reason for the very small portion of total coverage of such topics, as they are very much in accordance with the stated purpose of *JSA*. The same sort of monopolizing topics has already been mentioned regarding the exclusive occurrence of *Infrastructure/Monuments* and *Civilization/Culture history* in *A*. Furthermore, AAS is the sole journal with papers on provenience, e.g identifying the point of origin of raw materials. There is nothing in the stated purpose hindering the publication of provenience studies in any of the journals. I find this absence particularly odd for *A* and *JAA*. Such singularities may only point to the limited scope of this analysis, restricted to a five year period. Still, the total absence of a topic over five years (e.g. a substantial issues and papers) might be telling for the general practice of that journal. When compared to the expected results postulated by the thought-experiment above, it is not surprising for some topics not to

occur in specific journals. Fragmentation and inefficiency might instead be indicated by the singular thematic treatment and an abrupt transition between journals – in contrast to a gradual shift as predicted by fall off-curves.

Some remark must be made to the fact that the journals classify their contributions in slightly different ways – a remark of great importance to this investigation. E.g. *A* provides a separate section for "discussion papers", thereby reserving the term "original paper" only for those presenting new empirical data. *JSA* and *IJHA*, make no such distinction. *EA*, *JAA* and *AAS*, makes no such distinction, while not including discussion papers in the first place.

As has become evident by the previous three points, one can delineate a distinct distribution of traits amongst the six journals. The same goes for the application of methods. Contrary to the ideal condition which predicted a substantial overlap, there are distinct connections between type of journal and the utilization of methods.

Direction of relevance

In sum, when a constellation of the above four parameters form separate and unconnected clusters, it might result in "islands" in the sea of knowledge. These are characterized by several factors, such as very low cross-referencing, treatment of unique topics and a narrow scope of utilized methods. There seems to occur some form of island formation, particularly amongst *JSA* (and to some degree) *IJHA*. Without any evaluative statement intended, it is safe to say that *JSA* and *IJHA* form one end of a hypothetical continuum ranging from basic science to externally oriented, socially engaged research. This is evident from their main reliance upon discussion as a favored method, that these two are the only ones dealing with heritage, making policy papers, raising normative research-questions, and the only ones receiving less than 1 % of their cites from *AAS* and *EA*.

The direction of relevance may amount to general areas of similar research interests, what might be named *spheres of influence.* Taken together, the findings presented above hint at some differences in conduct, and it is my claim that they result from differing orientations towards explanatory ideals facilitated by the science/humanities-divide. As such, the spheres of influence might be the best indicator of diversification, potential fragmentation and incommensurability in archaeology. In the following discussion, I propose that the reason for the variation between journals (and the other types of deviation from the thought-experiment) stems from differing views on archaeology as a science.

Theoretical discussion: Epistemological implications

So far, the analysis has been mainly empirical. Thus the question of what might cause the observed patterns still remain. In the following, I suggest that the data point at a continued relevance of the science/ humanities-divide in the conduct of archaeology (figure 5). As the most fundamental premise, I take diverging orientations towards scientific and humanistic ideals to represent different and opposing *epistemologies*, that is – different ways of knowing, which proscribe different ways of producing knowledge. As commensurability presupposes a common standard for comparability between two sets of elements, opposing epistemologies within the same discipline may present a challenge to the accumulation of knowledge. There have been prolonged debates over the impact of a humanistic/scientific dualism upon archaeology´s ability to efficiently accumulate knowledge of diverse epistemic underpinnings – some claiming that the cementation of a dualism between humanistic and scientific orientations has already produced epistemologically incompatible approaches (Kristiansen 2004:77; Preucel 2001:15647; cf. Boivin 2005:177; Burdukiewicz 2006; Dark 1992; Kristiansen 2014). Others maintain that there are no factual basis for invoking such a chasm (Killick 2005:186, 188; cf. Trigger 1998:1). In order to better comprehend the connection between the science/humanities-divide and incommensurability, we need first to assess the practical and epistemic division of labor between distinct disciplines and sub-fields of archaeology (cf. Weisberg and Muldoon 2009).

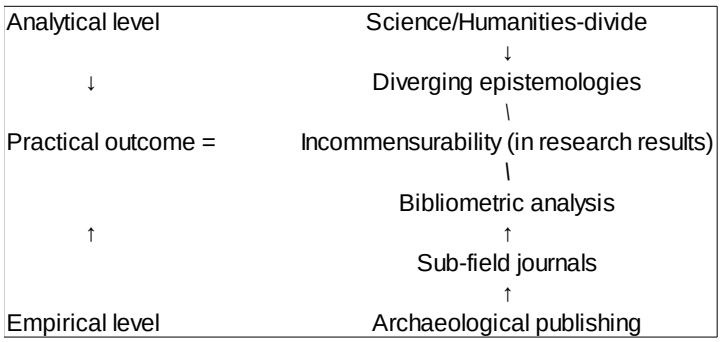


Figure 5. Illustrating the line of argument. The empirical level was provided above. Now approaching incommensurability from the analytic level. Arrows mark affirmed connections between levels, while dashes mark uncertain connections to be explored below. The model implies that the practical outcome of incommensurability is approachable from both angles.

Specialization and fragmentation

At any time there are two forces that act upon a discipline: The force of specialization and the force of fragmentation – both being an integral part of academic practice (Lawson 1991). The first may been named a positive effect of expertise, and the second an unfortunate effect.

In normal language, *specialization* refers to the process of developing knowledge from a general state to a more focused and thereby specialized state. The medical usage might be more informative in this case though, defined by *Merriam-Webster* (2015) as a "structural adaptation of a [...] part to a particular function". By this definition, specialization fulfills the ever growing demand for better and more precise knowledge. Specialization therefore allows for an extended division of labor between distinct groups, each of which are responding to ever more specific functions/tasks. The bibliometric results documented the same process in archaeology, witnessed by the unequal thematic and methodological priorities of the six sub-field journals. The benefit of specialization is a more efficient division of labor, as each group is able to fully concentrate of particular problems as they build on each other. As a result, specialization leads to co-dependency as no single group can perform the full range of necessary tasks.

Fragmentation on the other hand, refers to the process by which a part is broken off or detached. The unfortunate effects of fragmentation becomes clear when occurring on an organized level, as it entails "the absence or underdevelopment of connections" between a whole´s constituent parts (Bigo and Negru 2008; Jones 2013; Rowland 2002). Whenever fragmentation inhibits communication and produces suboptimal conditions for specialization, the co-dependence of specialists becomes unreliable, making each group perform overlapping functions and hindering fruitful accumulation of knowledge.

The intermediary process linking specialization and fragmentation is *departmentalization* – a process by which activities are grouped into departments which provide coordination between the division of labor amongst specialists (cf. Mintzberg 2007:101). The relation between all three processes, and their potential outcome, is depicted in the sequence below (figure 6).

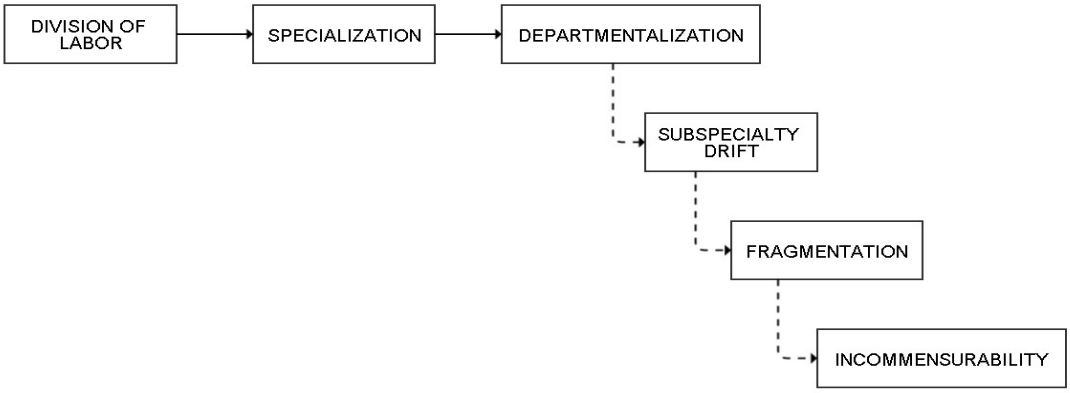


Figure 6. The sequence from simple division of labor to potential incommensurability. Solid lines mark established connections. Potential results of the sequence are marked by dotted lines.

When this sequence is implemented, through the division of labor – which allows for specialization, and the coordination of specialists by departmentalization – a potential chain of events may be initiated: As departmentalization sets in, the continued communication between departments can be more difficult to uphold. Departmentalization in itself presents no obstacle to efficient accumulation of specialist knowledge. It is only when groups of specialists leave their discipline of origin to form their own unlinked sub-fields, what is known as "subspecialty drift" (Hand and Judkins 1999), that the consequence might be fragmentation. Prolonged fragmentation may result in separate "cultures" proscribing different ways of doing archaeology, developing distinct languages, and more significantly, opposing epistemologies. The outcome of the fragmented sub-fields may then become incommensurable, in which communication and accumulation of knowledge get obscured.

This sequences brings us back to the main point of this paper – bridging the results of a bibliometric analysis and the identification of some of archaeology´s epistemic qualities. My point being that if subspecialty drift occurs, then fragmentation is likely to follow, and incommensurability might ensue, due to the lack of an organizing and general framework able to integrate the variability in conduct resulting from subspecialty drift. The bibliometric analysis showed that a division of labor was already set in place by the different statements of purpose, encouraging specialization. Departmentalization is observable through the many institutional affiliations of archaeology around the world, and the citation network-analysis is indicative of subspeciality drift (see table 5 and figure 4).

Fragmentation can occur in all parts of organized life, but our interest here is in academic practice. The critical reader may very well argue that the forces of specialization and fragmentation are equally balanced in both sciences and humanities. The critic might argue that the degree of fragmentation corresponds to the degree of specialization, and that this is as much the case in the natural sciences as in any other intellectual pursuit. But is this really the case? There are no inhibiting fragmentation in the natural sciences, in the sense postulated by the critic. Even though there might have been similar conditions in biology, chemistry and physics at an earlier stage of development, there is now an agreed-upon conceptual framework in all the natural sciences (Hacking 2012:ix-x): In physics there is the standard model, in biology the new synthesis of evolution and genetics, and in chemistry the implementation of the atomic theory, and later, quantum mechanics.

The point of this excursion into other areas of science is to remind the reader of the value and necessity of a common framework for explanation. One of its many important

functions is to counteract the fragmentation that is more characteristic of the humanistic disciplines. Taking the bibliometric results into account, archaeological sub-fields seems to be balancing the science/humanities-continuum. This is most clearly witnessed by the level of zero-cites specific to the different branches of academia. Undeterred by the multiple views on archaeology as more or less a hard science, the sheer possibility of opposing epistemologies being operational within different sections of archaeology needs further investigation, as the prime result of epistemic divergence is incommensurability.

Incommensurability

Although a concept of multiple origins (Duhem 1991; Feyerabend 1951, 1978:108; Oberheim and Hoyningen-Huene 2013), Thomas Kuhn put "incommensurability" at center stage with the publication of *The Structure of Scientific Revolutions* [1962]. Rather then invoking the concept of "paradigms", my usage of "commensurability" is detached from his overall conceptual apparatus, as I do not intend to bring back the debate over the usefulness of the rest of Kuhn´s terminology. I am therefore proposing a usage of Kuhn that differs from most archaeological applications, which has often been restricted to the dialectics of paradigm change, particularly when debating the transition between processualism and post-processualism (Bintliff 2011:7; Bintliff and Pearce 2011:4).

I find the methodological form of incommensurability[5] most useful when discussing archaeology, according to which «there is no common measure between successive scientific theories, in the sense that theory comparison is sometimes a matter of weighing historically developing values, not following fixed, definitive rules» (Hoyningen-Huene and Sankey 2001:vii-xv). "The proponents of competing paradigms are always at least slightly at cross-purposes. Neither side will grant all the non-empirical assumptions that the other side needs in order to make its case. […] the proponents of competing paradigms will often disagree about the list of problems that any candidate for paradigm must resolve. Their standards or their definitions of science are not the same" (Kuhn 2012:147). The crucial point of these statements is that there is more to commensurability than a mere translation and comparison of differing sets of statements, as the questions being asked and the ambition of problem solving itself is under scrutiny. This is what I take to be an important part of any epistemology informing research.

5 Within and amongst Kuhns own writing one can distinguish three phases in his definition of the concept "incommensurability" (Rosa 2000; Sankey 1993, 1998; cf. Oberheim and Hoyningen-Huene 2013). I´m naming this to illustrate the variety the concept exhibits, and therefore, something being commensurable, does not in it self specify *in what form*.

Turning to archaeology, this problem translates well to the local science/humanities-divide, due to the different epistemologies of humanistic and scientific disciplines. The take on archaeology as a scientific/humanistic endeavor determines what research questions are of interest and what constitutes adequate explanations. Indicating such discrepancy, the bibliometric analysis (see table 3) indicated some clearly defined thematic areas dealt with in specific sub-fields by means of separate sets of methods. This is taken to mirror different underlying epistemic positions of the sub-disciplinary journals. Rather than the observable practices of archaeological sub-fields resulting from epistemic positions excluding a range of topics, I claim that the explanatory ideal which corresponds to the take on archaeology as a scientific or humanistic discipline, affects both the willingness and ability of archaeological research to provide satisfactory answers to a given problem statement. Interestingly, bibliometric studies of the hierarchy of sciences have provided evidence for the unequal chance of disciplines reporting positive results: Softer sciences report positive results up to five times more often than harder sciences, porpurtedly due to different standards of validation and a less rigorous requirements put on hypothesis testing (Fanelli 2010).

Does this and the bibliometric results indicate incommensurability? Not necessarily I hold. What *would* pinpoint incommensurability is the potential of different investigations reaching opposing conclusions regarding a fixed data set due to distinct conceptual frameworks. The main point of interest in such conflict cases is not the diverging research results in themselves. Rather, it is the initial reason for the potential divergence. Kuhn names some candidates, one of worldview, linguistic and taxonomic incommensurability (Rosa 2000:61). Taxonomic incommensurability provides an epistemological reason for such a possibility, claiming that incongruent conceptual schemes building on different epistemologies, result in an incomplete translation and comparison: The struggle to define archaeology as either a becoming science or a humanistic endeavor has taken up much of the discipline´s intellectual history. The fundamental reason for this ongoing debate lies not in differences of terminology (which might also contribute), but in the opposing epistemologies that are employed as points of reference. As archaeologists of different molds, research interests and affiliations practice archaeology, they base their reasoning on what they deem archaeology to be and what explanatory ideal they see fit – be it the hermeneutic interpretation of unique events or subsuming particulars under generals. This was observed in the empirical analysis above, described as spheres of influence and the direction of relevance.

It follows, that the degree to which two opposing conceptions of archaeology´s

foundation as a scientific/humanistic endeavor are thought to be incommensurable, ultimately depends on what role is ascribed to the *equivalence* of archaeological knowledge production. Equivalence implies the necessity of two identical sets of data having the same content. Translated into the case of rival practices in archaeology, this means that identical data sets must result in equal conclusions, if not extra-empirical factors of the specific orientation interferes. If the specific conduct of different projects actively affect the resulting conclusions, the results become relativized and incommensurable. Archaeological data is not able to provide such equivalence in most cases. The very reason for this, is that archaeological data are empirically underdetermined – in other words, that "the evidence available to us at a given time may be insufficient to determine what beliefs we should hold in response to it" (Stanford 2013; cf. Laudan and Leplin 1991; Acuña and Dieks 2014). I suggest that empirical underdetermination is what makes it possible for opposing epistemologies to arise in archaeology in the first place. In such an instance one might assume that a shared superstructure would help in making the total body of disciplinary practice coherent. Coherence would be achieved by the superstructure guiding archaeology in the difficulties of studying an inherently undetermined data source. Providing some common protocols and shared practices would probably be the most fruitful remedy for incommensurability. Such a superstructure is what Kuhn termed "paradigm".

I will now examine one of several potential reasons for the lack of a consensual superstructure, in claiming that archaeological knowledge production is particularly constrained by the "vagueness" of the empirical record due to its underdetermination.

Vagueness

The recent literature on incommensurability has shifted towards concepts such as "vagueness" and "indeterminacy" (Qizilbash 2014:141; cf. Broome 1997; Qizilbash 2000). While closely related to uncertainty (a state of insufficient information), vagueness fundamentally concerns epistemic borderline cases, and poses a challenge to the precision of our knowledge in two ways (Sorensen 2013; cf. Gebhardt and Kruse 1993):

1. Relative vagueness: When a question is clear but our means for answering it are incomplete.
2. Absolute vagueness: When there are incompleteness in a question itself, and if no possible method of inquiry can settle the matter.

The value of "vagueness" becomes clear when returning to figure 1, the stacked percentage

diagram. It showed the almost perfect alignment of methods used within specific journals. If these methods are arranged on a scale from low to high precision, the scale would correspond to the abstract nature of phenomena studied by a given method. Concrete phenomena (particularly material ones) generally exhibit low vagueness, while immaterial events generally exhibit high vagueness. The uncertainties of archaeological data often takes the form of non-representativeness and bad preservation, but of greatest importance is the limited information value inherent in archaeological objects – often resulting in empirical underdetermination of archaeological interpretations of the past. Accordingly, only some questions about the past are answerable with reference to the archaeological record, while others are like squeezing blood from a stone: It does not matter how hard you squeeze if you are trying to obtain a result from an unyielding source.

To my understanding, archaeology´s diversity result from the multiplicity of objects that can be subjected to archaeological examination. As tautological as this might seem, I propose a model in which differing sub-fields specialize in separate spectra of phenomena, ranging from the concrete to the abstract (cf. Hawkes 1954). As research moves along the line of abstraction (of actual phenomena), it will also move towards vagueness (of description), as shown in table 6. Archaeology seems to incorporate both relative and absolute vagueness, but their composition depends on the objects and phenomena being studied, as well as the methods used. As specific journals deal with different topics, they will also relate to different degrees of either relative or absolute vagueness. I find this substantiated by the results of thematic distribution, presented in table 3.

Table 6. Illustration of the connection between the two continuums and the resulting vagueness.

Phenomena ↓ / Description→	**Precise**	**Vague**
Concrete	X (relative vagueness)	-
Abstract	-	Y (absolute vagueness)

Returning to the initial concern – how diverse conduct pose a challenge to the commensurability of research results – this may be analyzed through the concepts introduced above. Archaeological subjects will exhibit different degrees of vagueness. Specific sub-fields focusing on different topics and applying opposing epistemologies, might make it harder to agree upon a common standard for explanation of the archaeological record. An end result could potentially be reduced commensurability of archaeological output, as well as posing some hindrance to the verifiability of knowledge claims.

Ensuring commensurability across the science/humanities-divide

What can be done about such inherent vagueness and potential incommensurability? Vagueness and incommensurability widens the gap separating archaeology´s explanatory ambitions (what archaeology wants to know) from the actual information value contained by archaeological data (the ability to know what it desires to know). They produce an asymmetrical relation between goals and actual goal-attainment. Some has presented the problem as a need to choose between scientific and humanistic ideals (Hastrup 1999:107; Jones 2001:1–2).

There are at least two axis that contribute to the humanities/sciences-continuum (Hastrup 1999:107). These axis constitute the core of archaeology´s foundational problems of self-perception, falling in between all the university departments, neither being a full-bodied hard science nor unsystematic intellectualism. The first axis is a matter of epistemology and concerns whether a) *knowledge* or b) *wisdom* most aptly represent the aim of academic scholarship. The second axis concerns whether the past should be described in terms of c) *pragmatics* or the inherent d) *meaning* of the lived past (on its own terms). I would further add a distinction of ontology, in what descriptions aim at grasping: 1) those describing states in, and properties of, the world, and 2) those describing the human experience(s).

It has been claimed that pragmatic descriptions of the past are characterized by a certain blindness towards the significance of the internal relations of social phenomenon (Hastrup 1999:109). This is a reasonable concern when coming from a humanistic viewpoint (or other research areas available to hermeneutic interpretation). Even so, it may be less appropriate when directed at archaeology. This is because the archaeological record cannot provide answers to a significant proportion of the questions raised regarding past meaning and significance – as was readily illustrated by archaeology´s insufficient ways of knowing much about the upper steps of Christopher Hawkes (1954) ladder of inference – e.g. vague and immaterial events. Even by giving this kind of critique its most beneficial interpretation, its is still the case that the archaeological record does not allow a free choice between equally valid and alternative explanatory models. I propose that archaeology relates to a pragmatic perspective on explanation of past phenomena, being both blessed and cursed at the same time by the limited data actually available. The blessing consists in a restricted supply of data, prohibiting archaeology from overwhelmed by its own data (as is arguably the case for the social sciences due their set of contemporary sources). This restriction provides a structure to the major subject that is the past, though admittedly a somewhat arbitrary one. The curse is,

as already mentioned, the simplistic representation archaeology may provide of an actual past, an unfortunate consequence following a relatively small set of potential sources.

I therefore claim that archaeology is better of treating its empirical record as the result of an interplay between external conditions and universal human needs/qualities, even though all is well aware of the fact that the actual past was as much shaped by an internal logic governing meaning and ideal culture (cf. Jones 2004:335). The point is this: As it it not possible (in any sound way) to detect internal psychological states, first person qualia, meaning and the like in archaeological data, we have to make the best out of it. Such a situation can be discouraging, making some archaeologists give up on the grand idea of a unified scientific community. But discouragement and despair on behalf of the inherent vagueness of the empirical record is exactly the opposite of what is needed. In the face of vagueness and uncertainty, the only remedy is dedication to minute detail, stringency, sobriety and the compliance with a set of basic rules which can govern and integrate research across sub-disciplinary specializations. The opposite would be encouraging disciplinary fragmentation and the incommensurability resulting from relativizing the epistemic framework of archaeology.

This is why I, at the best of my knowledge, cannot see any other option for archaeology than to orient itself after the paradoxical and twofold claim of 1) truth, and 2) the heuristics of a pragmatic take on explanation. The paradox consists in both aiming at truth, and at the same time knowing that truth is practically unattainable due to the limited information value of the archaeological record, and the corresponding heuristics of archaeological explanations. To ensure commensurability at the basic level, there must first be an agreement on whether the purpose of archaeology is knowledge or wisdom, as they provide differing conceptual frameworks. I claim that it should be the first, as claims of wisdom (as important as they may be) are not accountable to the same standards of validation as knowledge: Wisdom is directed at the best way of life, while knowledge on the other hand, accumulates successful instances of correspondence between the external world and our perceptions of it. Accepting truth and knowledge as the ultimate aim also entails an epistemological view of archaeology in favor of being a scientific endeavor.

What should be kept in mind is that the potential incommensurability of opposing views on archaeology as a scientific/humanistic endeavor does not exclude the possibility of compering *technical results* (Hacking 2012:xxxii; cf. Kuhn 1977:339). This is what the surviving value of incommensurability consists in, being an analogy to specialization by

natural evolution and "subspecialty drift": "Just as new species are characterized by the fact that they do not interbreed, so new disciplines are to some extent mutually incomprehensible. This is the use of the idea of incommensurability that has real content. It has nothing do to with pseudo-questions about theory choice" (Hacking 2012:xxxii). Thus there are no principal reason hindering a general framework from coordinating archaeological research (as technical results can be compared and evaluated). The only problem occurs if different standards of validation and norms for evaluation are applied at the same time. The most important function a common framework performs is providing a set of criteria for the validation and evaluation of knowledge claims, facilitating an efficient comparison between research results and the subsequent cumulative integration of results into a more coherent structure than would have been possible to achieve otherwise.

Comparability is therefore attainable, in spite of potentially incommensurable stances/conduct/perceptions. Through comparability, evaluation is ensured, thus making it both possible and necessary that some explanations and descriptions will be better, more accurate and correct than others. As long as some success in identifying real properties of the past through archaeological inquiries and methods is admitted, I claim that one must attribute such a success to the truthful directedness of archaeological knowledge production. In the end, I think it fair to adopt a mild scientific realism on behalf of archaeology, thereby postulating that the past is (in principal) ontologically independent of our perceptions, and that some aspects of past reality is accessible to us by archaeological means. Such a claim might be self-evidently true to almost all practicing archaeologists, but it still needs to be stated explicitly, as this is the principal reason enabling the separation of archaeological truth claims from fiction and blind guessing.

If archaeology aim at truth, it is through the production of knowledge instead of wisdom, thereby making the goal of archaeology fundamentally the same as the other sciences. The past is no less a phenomena worthy of scientific study, than any other subject. Instead of insisting on modeling all science to the success of physics, a conception of archaeology as part and extension of the historical sciences has been proposed (Cleland 2001, 2002, 2011; Cleland and Brindell 2013). I regarding this as a constructive proposition, placing archaeology in family with astronomy, geology and paleontology.

What is thought of archaeology´s potential as a science is not of grave importance. The real significance lies in the epistemic possibilities of a common framework securing the efficient accumulation of knowledge production no matter the personal hinge, be it

humanistic of scientific. Drawing on an old debate, one might want to consider the possibility of uniting knowledge from both sides of the science/humanities-divide. Such a unity of knowledge has been postulated under the heading of the *consilience-thesis*, "literally the "jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation" (Wilson 1999:8; cf. Descartes 1662; Whewell 1840). "The main thrust of the consilience world view [...] is that culture and hence the unique qualities of the human species will make complete sense only when linked in causal explanation to the natural sciences" (Wilson 1999:267).[6] I can think of few other disciplines better positioned to bridging the two cultures-divide, than precisely archaeology.

Conclusion

It is open to debate whether or not the epistemological concepts introduced in this paper provides a fitting description of the contemporary state of archaeology. As it is beyond the scope of this paper to fully account for the relation between diverse publication practices and epistemological consequences, the concepts of fragmentation, incommensurability and vagueness has been employed as heuristics in order to arrive at a tentative interpretation of the bibliometric results. The bibliometric data point to some significant differences in the practical conduct of archaeological sub-fields, with varying:

- number of zero-cites (indicative of the science/humanities-spectrum)
- directions of relevance and spheres of influence
- citation-networks (cross-referencing)
- thematic distributions
- unequal application of methods
- scope of journals dictated by the respective statements of purpose

It was proposed that these results correspond to a pattern to be expected of a somewhat fragmented discipline. It has been my claim that the cause of such apparent fragmentation is the continued relevance of the scientific/humanistic-divide in providing sub-fields with opposing epistemologies.

In concluding this paper I wish to remark that there are no direct standard for accumulation and comparison of research results in archaeology, and that this is due to the

6 When brought to its logical conclusion, it states that "all tangible phenomena […] are based on material processes that are ultimately reducible, however long and tortuous the sequences, to the laws of physics" (Wilson 1999:266). This statement might seem overtly deterministic to the liking of archaeologists, but what must be kept in mind is that such an ontological reductionism does not have to exclude free will – what is known as the "compatibilist view" (see McKenna 2009).

variability in practical conduct. One may disagree on whether this condition is harmful or not. To this I have claimed that what is at stake is the discipline´s ability to evaluate proposed results and claims of the past, and thereby the future prospect of archaeology itself.

I do not think the result of diverse conduct of archaeological sub-fields can support claims of incommensurability. The possibility of compering technical results should go against such claims. Still, a comparison of results necessitates a common framework and a set of rules for validating and evaluating research results, which is not found to be commonly shared amongst archaeological sub-fields. What I do think though, is that the phenomena studied by the different sub-fields exhibit different degrees of vagueness. The specific conduct of sub-fields will therefore assimilate the vagueness characterizing its main area of interest, and make the sub-field look for a fitting set of methods, theories and a general sphere of influence in order to cope with the vagueness of its data. This seems to result in a lack of a common framework that can coordinate archaeological research. At this point, the analyzed sub-fields overlap to a degree that cannot be the result of an ideal state of perfectly functional and efficient division of labor. I am of the opinion that diversity in archaeology is a double-edged sword: Stimulating creativity and innovation, while at the same time hindering the effectiveness of a normal science to solve problems. This is what became clear by the discussion of forces at work in academic disciplines: Specialization provides efficient accumulation of a narrow field of knowledge, while fragmentation results in a multifaceted and less coherent knowledge production. In its utmost consequence, the lack of a common framework may result in an inefficient division of labor, having to solve and present extra-empirical problems for every project individually, instead of referring to defined standards.

Not being able to discuss the layout for such a common framework here, I must confine myself to state only what must be considered the bare minimum criteria that needs to be settled on a collective scale: What questions are actually answerable through the use of archaeological data, and does distinct types of data necessitate distinct types of description and explanation? A preliminary conclusion to such matters may be provided by the discussions presented here, as the underdetermination of archaeological data and the lack of logical equivalence in inferences promotes the possibility of opposing epistemologies in archaeology. In the long run, such epistemological diversity may result in incommensurability.

References

Acuña, Pablo, and Dennis Dieks
2014 Another look at empirical equivalence and underdetermination of theory choice. *European Journal for Philosophy of Science* 4(2): 153–180.

Anon
The San Francisco Declaration on Research Assessment (DORA). *The San Francisco Declaration on Research Assessment (DORA)*.

Atalay, Sonya
2008 Multivocality and Indigenous Archaeologies. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 29–44. Springer New York, January 1.

Batista, Pablo D., Mônica G. Campiteli, and Osame Kinouchi
2006 Is it possible to compare researchers with different scientific interests? *Scientometrics* 68(1): 179–189.

Bellis, Nicola De
2009 *Bibliometrics and Citation Analysis: From the Science Citation Index to Cybermetrics*. The Scarecrow Press, Inc., Lanham, Md, May 16.

Bell, James A.
1994 *Reconstructing Prehistory: Scientific Method in Archaeology*. Temple University Press, Philadelphia.

Bergsvik, K. A.
2001 Pragmatisme og arkeologi. *Primitive Tider*: 73–90.

Bigo, Vinca, and Ioana Negru
2008 From fragmentation to ontologically reflexive pluralism. *Journal of Philosophical Economics*.

Binford, Lewis R.
1962 Archaeology as Anthropology. *American Antiquity* 28(2): 217–225.
1981 *Bones: Ancient Men and Modern Myths*. Academic Press Inc, New York, July.

Binford, L.R.
1965 Archaeological Systematics and the Study of Culture Process. *American Antiquity* 21(2): 203–210.

Binford, L. R.
2001 *Constructing Frames of Reference: An Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets*. University of California Press, Berkeley, June 4.

Bintliff, John
2011 The Death of Archaeological Theory? In *The Death of Archaeological Theory?*, pp. 7–22. Oxbow Books, Oxford, UK ; Oakville, CT, September 15.

Bintliff, John, and Mark Pearce (editors).
2011 *The Death of Archaeological Theory?*. Oxbow Books, Oxford, UK ; Oakville, CT, September 15.

Blakey, Michael L.
2008 An Ethical Epistemology of Publicly Engaged Biocultural Research. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 17–28. Springer New York, January 1.

Boivin, N.
2005 Comments I: Post-Textual Archaeology and Archaeological Science. *Archaeometry* 47(1): 175–179.

Broadus, R. N.
1987 Toward a definition of "bibliometrics." *Scientometrics* 12(5-6): 373–379.

Brookes, B. C.
1990 Biblio-, sciento-, infor-metrics??? What are we talking about. In *Informetrics*, edited by L. Egghe and R. Rousseau, pp. 31–43.

Broome, John
1997 Is Incommensurability Vagueness? In *Incommensurability, Incomparability and Practical Reason*, edited by Ruth Chang. Harvard University Press.

Clarke, David L.
1978 *Analytical archaeology*. Ed. Bob Chapman. 2nd ed. Methuen.
1979 *Analytical archaeologist: collected papers of David L. Clarke*. Academic Press, New York.

Cleland, Carol E.
2001 Historical science, experimental science, and the scientific method. *Geology* 29(11): 987.
2002 Methodological and Epistemic Differences Between Historical Science and Experimental Science. *Philosophy of Science* 69(3): 447–451.
2011 Prediction and Explanation in Historical Natural Science. *The British Journal for the Philosophy of Science* 62(3): 551–582.

Cleland, Carol E., and Sheralee Brindell
2013 Science and the Messy, Uncontrollable World of Nature. In *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*, edited by Massimo Pigliucci and Maarten Boudry, pp. 183. University of Chicago Press.

Dark, Ken
1992 The Science of Archaeology. *Philosophy Now* 3: 21–22.

Darvill, Timothy
2008a Pluralism. *The Concise Oxford Dictionary of Archaeology*. Oxford University Press, Oxford.
2008b Multivocality. *The Concise Oxford Dictionary of Archaeology*. Oxford University Press, Oxford.

Descartes, René
1662 *De Homine Figuris Et Latinitate Donatus a Florentio Schuyl*. Ed. Florentio Schuyl. Lugduni Batavorum.

Duhem, Pierre Maurice Marie
1991 *The Aim and Structure of Physical Theory*. Trans. Philip P. Wiener. Reprint edition. Princeton University Press, Princeton, July 29.

Dunnell, R. C.
1971 *Systematics in Prehistory*. The Free Press, New York.
1989 Philosophy of science and archaeology. In *Critical Traditions in Contemporary Archaeology: Essays in the Philosophy, History, and Socio-politics of Archaeology*, edited by Valerie Pinsky and Alison Wylie. CUP Archive, London.

Embree, Lester (editor).
1992 *Metaarchaeology - Reflections by Archaeologists and Philosophers*. Kluwer Academic Publishers, Boston.

Fahlander, Fredrik
2012 Are we there yet? Archaeology and the postmodern in the new millennium. *Current Swedish Archaeology* 20: 109–129.

Fanelli, Daniele
2010 "Positive" Results Increase Down the Hierarchy of the Sciences. *PLoS ONE* 5(4): e10068.

Fanelli, Daniele, and Wolfgang Glänzel
2013 Bibliometric Evidence for a Hierarchy of the Sciences. *PLoS ONE* 8(6): e66938.

Feyerabend, Paul
1951 *Zur Theorie der Basissätze (phd. dissertation)*. P. Feyerabend, Universität Wien.
1978 *Science in a Free Society*. Verso, London, January 1.

Fog, Agner
2009 An Evolutionary Theory of Cultural Differentiation. *Theoretical and Methodological Issues in Evolutionary Archaeology*: 31–34.

Fricker, Miranda
2009 *Epistemic Injustice: Power and the Ethics of Knowing*. Oxford University Press, Oxford; New York, September 28.

Gardin, J. C.
1980 *Archaeological Constructs: An Aspect of Theoretical Archaeology*. Cambridge University Press, Cambridge Eng. ; New York, March 31.

Garfield, E.
1983 *Citation Indexing. Its Theory and Application in Science, Technology, and Humanities*. ISI Press, Philadelphia

Gebhardt, Jörg, and Rudolf Kruse
1993 The context model: An integrating view of vagueness and uncertainty. *International Journal of Approximate Reasoning* 9(3): 283–314.

Gero, Joan M.
2007 Honoring Ambiguity/Problematizing Certitude. *Journal of Archaeological Method and Theory* 14(3): 311–327.

Gers, Matt
2011 The long reach of philosophy of biology. *Biology & Philosophy* 26(3): 439–447.

Glänzel, Wolfgang
2002 A Concise Introduction to Bibliometrics & its History.

Gross, P. L. K., and E. M. Gross
1927 College Libraries and Chemical Education. *Science* 66(1713): 385–389.

Habu, Junko, and Clare Fawcett
2008 Science or Narratives? Multiple Interpretations of the Sannai Maruyama Site, Japan. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 91–117. Springer New York, January 1.

Habu, Junko, Clare Fawcett, and John M. Matsunaga
2008 Introduction: Evaluating Multiple Narratives: Beyond Nationalist, Colonialist, Imperialist Archaeologies. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M.

Matsunaga, pp. 1–11. Springer New York, January 1.

Hacking, Ian
2012 Introductory essay. In *The Structure of Scientific Revolutions: 50th Anniversary Edition*, pp. Vii–xxxvii. Fourth Edition edition. University Of Chicago Press, Chicago ; London, April 30.

Hand, Carl M., and Ben Judkins
1999 Disciplinary schisms: Subspecialty "drift" and the fragmentation of sociology. *The American Sociologist* 30(1): 18–36.

Harlow, Kristance
2011 Multivocality of Archaeology Handbooks: Publication Patterns, Gender, and Networking.

Hastrup, Kirsten
1999 *Viljen til viden: en humanistisk grundbog*. Gyldendal A/S, Copenhagen.

Hawkes, Christopher
1954 Archeological Theory and Method: Some Suggestions from the Old World. *American Anthropologist* 56(2): 155–168.

Hodder, Ian
2000 *Towards Reflexive Method in ArchaeologTowards Reflexive Method in Archaeology: The Example at Çatalhöyük*. McDonald Institute for Archaeological Research and British Institute of Archaeology at Ankara, Cambridge.
2004 *Archaeology Beyond Dialogue*. 1st Edition edition. University of Utah Press, Salt Lake City.
2005 Reflexive methods. In *Handbook Of Archaeological Methods 2 volume set*, edited by Herbert D. G. Maschner and Christopher Chippindale, pp. 643–669. AltaMira Press, Lanham, MD, November 17.
2008 Multivocality and Social Archaeology. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 196–200. Springer New York, January 1.
2012 *Archaeological Theory Today*. Polity, March 19.

Hoyningen-Huene, P., and H. Sankey
2001 Introduction. In *Incommensurability and Related Matters*, edited by P. Hoyningen-Huene and H. Sankey, 216:pp. vii–xxxiv. Boston Studies in the Philosophy and History of Science. Kluwer, Dordrecht: Kluwer.

Jameson, John H. Jr.
2014 Toward Multivocality in Public Archaeology: Public Empowerment Through Collaboration. In *Between the Devil and the Deep*, edited by Della A. Scott-Ireton, pp. 3–10. When the Land Meets the Sea 5. Springer New York, January 1.

Jones, A.
2001 *Archaeological Theory and Scientific Practice | Archaeological theory and methods*. Cambridge University Press.
2004 Archaeometry and materiality: materials-based analysis in theory and practice*. *Archaeometry* 46(3): 327–338.

Jones, Glen A.
2013 The horizontal and vertical fragmentation of academic work and the challenge for academic governance and leadership. *Asia Pacific Education Review* 14(1): 75–83.

Killick, D.
2005 Comments Iv: Is There Really a Chasm Between Archaeological Theory and Archaeological Science? *Archaeometry* 47(1): 185–189.

Killick, David, and Suzanne M.M. Young

1997 Archaeology and archaeometry: from casual dating to a meaningful relationship? *Antiquity* 71(273): 518–524.

Kim, Minkoo
2008 Multivocality, Multifaceted Voices, and Korean Archaeology. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 118–137. Springer New York.

Kristiansen, Kristian
2004 Genes versus agents. A discussion of the widening theoretical gap in archaeology. *Archaeological Dialogues* 11(02): 77–99.

Kuhn, Thomas S.
1977 Objectivity, Value Judgment, and Theory Choice. In *The Essential Tension*, pp. 320–39. University of Chicago Press.
2012 *The Structure of Scientific Revolutions: 50th Anniversary Edition*. Fourth Edition edition. University Of Chicago Press, Chicago ; London, April 30.

Larivière, Vincent, Yves Gingras, and Éric Archambault
2009 The decline in the concentration of citations, 1900–2007. *Journal of the American Society for Information Science and Technology* 60(4): 858–862.

Larivière, Vincent, George A. Lozano, and Yves Gingras
2014 Are elite journals declining? *Journal of the Association for Information Science and Technology* 65(4): 649–655.

Laudan, Larry, and Jarrett Leplin
1991 Empirical Equivalence and Underdetermination. *Journal of Philosophy* 88(9): 449–472.

Lawson, Hal A.
1991 Specialization and Fragmentation Among Faculty as Endemic Features of Academic Life. *Quest* 43(3): 280–295.

Leydesdorff, Loet, Björn Hammarfelt, and Almila Salah
2011 The structure of the Arts & Humanities Citation Index: A mapping on the basis of aggregated citations among 1,157 journals. *Journal of the American Society for Information Science and Technology* 62(12): 2414–2426.

Lotka, Alfred J.
1926 The frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences* 16(12): 317–324.

Lozano, George A., Vincent Larivière, and Yves Gingras
2012 The weakening relationship between the impact factor and papers' citations in the digital age. *Journal of the American Society for Information Science and Technology* 63(11): 2140–2145.

Lyman, R. Lee, and Michael J. O'Brien
1998 The Goals of Evolutionary Archaeology: History and Explanation. *Current Anthropology* 39(5): 615–652.

Mallía, Ma Soledad, and Aixa Solange Vidal
2009 From the Opposite Corner: A Bibliometric Analysis of Research on American Archaeology in European Publications. *Archaeologies* 5(3): 446–467.

Martinón-Torres, Marcos and Killick, David
2015 Archaeological Theories and Archaeological Sciences. The Oxford Handbook of Archaeological Theory. Edited by Andrew Gardner, Mark Lake, and Ulrike Sommer (Forthcoming)

Accessible at:
http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199567942.001.0001/oxfordhb-9780199567942-e-004

Mays, S.
2010 Human osteoarchaeology in the UK 2001–2007: a bibliometric perspective. *International Journal of Osteoarchaeology* 20(2): 192–204.

McKenna, Michael
2009 Compatibilism. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta.

Merriam-Webster
2015a "Commensurable". Merriam-Webster.com. Accessed May 11, 2015. http://www.merriam-webster.com/dictionary/commensurable.
2015b "Fragmentation". Merriam-Webster.com. Accessed May 11, 2015. http://www.merriam-webster.com/dictionary/fragmentation.

Mesoudi, Alex
2011 *Cultural Evolution: How Darwinian Theory Can Explain Human Culture and Synthesize the Social Sciences*. University Of Chicago Press, Chicago ; London, September 1.

Mesoudi, Alex, Andrew Whiten, and Kevin N. Laland
2006 Towards a unified science of cultural evolution. *Behavioral and Brain Sciences* 29(04): 329–347.

Mintzberg, Henry
2007 *Mintzberg on Management*. Free Press, New York; London, August 21.

Mrozowski, Stephen A.
2012 Pragmatism and the Relevancy of Archaeology for Contemporary Society. In *Archaeology in Society*, edited by Marcy Rockman and Joe Flatman, pp. 239–256. Springer New York, January 1.

Nalimov, V. V., and B. M. Mulchenko
1971 *Measurement of science: Study of the development of science as an information process*. Foregin Technology Division, Washington, DC.

Norris, Michael, Charles Oppenheim, and Fytton Rowland
2008 The citation advantage of open-access articles. *Journal of the American Society for Information Science and Technology* 59(12): 1963–1972.

Oberheim, Eric, and Paul Hoyningen-Huene
2013 The Incommensurability of Scientific Theories. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta. Spring 2013.

O'Brien, Michael J., R. Lee Lyman, and Robert D. Leonard
1998 Basic Incompatibilities between Evolutionary and Behavioral Archaeology. *American Antiquity* 63(3): 485.

Palomar, T., M.Y García-Heras, and M.A. Villegas
2009 Archaeological and historical glasses: A bibliometric study. *Boletin de la Sociedad Española de articulo Cerámica y Vidrio* 48(4): 187–194.

Penfield, Teresa, Matthew J. Baker, Rosa Scoble, and Michael C. Wykes
2014 Assessment, evaluations, and definitions of research impact: A review. *Research Evaluation* 23(1): 21–32.

Polanyi, Michael

1958 *Personal Knowledge*. The University of Chicago Press.

Preucel, R. W.
2001 Theory in Archaeology. In *International Encyclopedia of the Social & Behavioral Sciences*, edited by Neil J. Smelser, Paul B. Baltes, pp. 15647–15652. Pergamon, Oxford.

Price, D. de Solla
1961 *Science since Babylon*. Yale University Press, New Haven.
1963 *Little Science, Big Science*. Columbia University Press, New York.

Pritchard, Alan
1969 Statistical bibliography or bibliometrics. *Journal of Documentation* 25(4).

Qizilbash, Mozaffar
2000 Comparability of Values, Rough Equality, and Vagueness: Griffin and Broome on Incommensurability. *Utilitas* 12(02): 223–240.
2014 "Incommensurability" and Vagueness: Is the Vagueness View Defensible? *Ethical Theory and Moral Practice* 17(1): 141–153.

Ravichandra, Rao I. K.
1983 *Quantitative methods for library and information science*. Wiley Eastern, New Delhi.

Riede, Felix, Jan Apel, and Kim Darmark
2012 Cultural evolution and archaeology. Historical and current trends. In . BAR International Series 2399. Archaeopress, Oxford, England.

Rosa, Pérez Ransanz Ana
2000 *Kuhn y el cambio científico*. 1st. edition. Fondo de Cultura Económica, México, December 31.

Rowland, Stephen
2002 Overcoming Fragmentation in Professional Life: The Challenge for Academic Development. *Higher Education Quarterly* 56(1): 52–64.

Rubin, R.
2010 Foundations of library and information science. Neal-Schman Publishers, New York.

Salmon, Merilee, H.
1982 *Philosophy and Archaeology*. Studies in Archaeology. Academic Press, New York.

Sankey, Howard
1993 Kuhn's Changing Concept of Incommensurability. *The British Journal for the Philosophy of Science* 44(4): 759–774.
1998 Taxonomic incommensurability. *International Studies in the Philosophy of Science* 12(1): 7–16.

Schiffer, Michael B.
1976 *Behavioral Archeology*. Percheron Press/Eliot Werner Publications, Clinton Corners, N.Y.
1996 *Formation Processes of the Archaeological Record*. 1st Edition edition. University of Utah Press, Salt Lake City.

Shanks, Michael, and Christopher Y. Tilley
1992 *Re-constructing Archaeology: Theory and Practice*. Psychology Press.

Silberman, Neil Asher
2008 Virtual Viewpoints: Multivocality in the Marketed Past? In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 138–143. Springer New York.

Silva, Filipe Carreira da, and Patrick Baert

2013 Evolution, Agency, and Objects: Re-Discovering Classical Pragmatism. In *Oxford Handbook of Archaeological Theory*, edited by A. Gardner, M. Lake, and U. Sommer. Oxford University Press, Oxford Forthcoming.

Solomon, David J., Mikael Laakso, and Bo-Christer Björk
2013 A longitudinal comparison of citation rates and growth among open access journals. *Journal of Informetrics* 7(3): 642–650.

Sorensen, Roy
2013 Vagueness. Ed. Edward N. Zalta. *The Stanford Encyclopedia of Philosophy*.

Stanford, Kyle
2013 Underdetermination of Scientific Theory. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta. Winter 2013.

Steup, Matthias
2014 Epistemology. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta. Spring 2014.

Trigger, Bruce G.
1998 Archaeology and Epistemology: Dialoguing across the Darwinian Chasm. *American Journal of Archaeology* 102(1): 1.
2006 *A History of Archaeological Thought*. 2 edition. Cambridge University Press, Cambridge England, New York.

Watson, Patty J.
1986 Archaeological interpretation 1985. In *American Archaeology, Past and Future: A Celebration of the Society for American Archaeology, 1935-1985*, edited by David J. Meltzer, Don D. Fowler, and Jeremy Arac Sabloff, pp. 439–457. Smithsonian Institution, Washington, DC.

Watson, Patty J., S.A. LeBlanc, and C.L Redman
1971 *Explanation in Archaeology: An Explicit Scientific Approach*. First Edition edition. Columbia Univ Pr, New York.

Weale, Andy R., Mick Bailey, and Paul A. Lear
2004 The level of non-citation of articles within a journal as a measure of quality: a comparison to the impact factor. *BMC Medical Research Methodology* 4(1): 14.

Webmoor, Timothy
2007 What about "one more turn after the social" in archaeological reasoning? Taking things seriously. *World Archaeology* 39(4): 563–578.

Weisberg, Michael, and Ryan Muldoon
2009 Epistemic Landscapes and the Division of Cognitive Labor. *Philosophy of Science* 76(2): 225–252.

Whewell, William
1840 *The Philosophy of the Inductive Sciences: Founded Upon Their History*. Vol. in two volumes. John W. Parker, London.

White, Leslie A.
1959 *The Evolution of Culture: The development of civilization to the fall of Rome*. McGraw-Hill, New York.

Whitley, Professor James
2001 *The Archaeology of Ancient Greece*. Cambridge University Press, Cambridge, U.K. ; New York.

Wilson, Edward Osborne
1999 *Consilience: The Unity of Knowledge*. Reprint edition. Vintage, New York, March 30.

Wylie, Alison
1999 Rethinking Unity as a "Working Hypothesis" for Philosophy: How Archaeologists Exploit the Disunities of Science. *Perspectives on Science* 7(3): 293–317.
2008 The Integrity of Narratives: Deliberative Practice, Pluralism, and Multivocality. In *Evaluating Multiple Narratives*, edited by Junko Habu, Clare Fawcett, and John M. Matsunaga, pp. 201–212. Springer New York.

Wylie, Alison, and M. J. Lynott
1995 *Ethics in American Archaeology: Challenges for the 1990s*. Society for American Archaeology, Washington, DC.

Paper 2

Identifying key factors affecting the "two cultures" relation of archaeology: Outlining a common epistemological platform for archaeology and archaeometry

Abstract: In relating to the debate over the nature of archaeology along the science/humanities-spectrum, this paper investigates some *epistemological* challenges arising from integrating scientific methodologies with archaeology. The main objective is to evaluate what epistemological platform might integrate archaeology and archaeometry in interdisciplinary research projects, and how such a platform might provide productive interdisciplinary research strategies. Four epistemic factors at individual levels are examined, consisting of 1) communication, 2) specialization, 3) explanatory ideals and 4) uncertainty levels and types. A model of interdisciplinary research strategies is put forth in order to cope with these cumulative and hierarchical epistemic challenges. The opposing results of stable isotope analysis and faunal remains regarding dietary change during the Mesolithic/Neolithic-transition are presented as a case study, identifying general epistemological factors affecting the application of scientific methodologies in archaeology.

Introduction

What might cause the relationship between the proposed "two cultures" of archaeology to result in a chasm between humanistic and scientific orientations? And does the "two cultures" chasm create unfavorable conditions for interdisciplinary cooperation with the sciences?

Much effort has been devoted into making the collaboration between archaeology and other fields of study as productive and constructive as possible (Kristiansen 2014:13-14). Although admitting the importance of such endeavors, and *interdisciplinarity* being a much favored term recently, the attention has mainly been directed at the practical and methodological factors affecting archaeology´s cooperation across disciplinary boundaries (Fogelin 2015; cf. Schiffer 1981). As it is beyond the scope of this paper to provide a complete description of the relationship between humanistic and scientifically oriented archaeology, the paper focuses on some *epistemological factors* affecting the outcome of interdisciplinary research between traditional archaeology and the scientific methodologies of archaeometry. The investigation focuses on "interdisciplinarity", as the integration of scientific methodologies in the pursuit of answers to archaeological research questions, is inherently an interdisciplinary matter. Furthermore, in proposing that the "two cultures" chasm in archaeology affects the cooperation between archaeology and the sciences, it is suggested that an increased understanding of what makes interdisciplinary research work in general, may inform future merging of science and archaeology.

The twofold objective of this paper is 1) to evaluate what epistemological platform might integrate differing participants in interdisciplinary archaeological research, and 2) how such a platform might provide productive interdisciplinary research strategies for the

integration of archaeology and archaeometry. Focus is directed at four epistemic challenges: 1) communication, 2) specialization, 3) explanatory ideals, 4) uncertainty levels and types. Being increasingly more fundamental and building upon each other, together these factors provide a vertical hierarchy of epistemological difficulties that might accumulate in interdisciplinary collaboration between archaeology and the sciences.

When considering the long history of cross-disciplinary cooperation and the diverse character of archaeology, it might seem counterintuitive that *interdisciplinarity* – the merging of disciplines in the pursuit of novel solutions to shared problems – has not been examined more thoroughly. Several papers have requested a stronger integration of archaeology and archaeometry (Borić et al. 2004:241; Mayle and Iriarte 2014; Miller 2013), but the founding preconditions of such integration have received little attention. One might therefore request performative, empirical and analytic investigations into the mechanisms of interdisciplinarity, going beyond prescriptive debate. It is my intention to contribute to such an investigation, making this paper meta-archaeological (cf. Embree 1992:3; Wylie 2001:617).

The paper makes a case study of the opposing results of two archaeometric analyzes regarding diet during the Mesolithic/Neolithic-transition in Northern Europe, focusing on the epistemic reasons for the discrepancy. After briefly reviewing some difficulties of integrating interdisciplinary research, primary focus is directed at the four above-mentioned factors. The diet case study provides concrete examples in the identification of some necessary properties of the common epistemic platform managing epistemological challenges in the archaeology/archaeometry-relation. In conclusion it is claimed that the integration of various specialists and methods entails not just the synthesizing of various elements at the *end* of a cross-disciplinary research project, but just as important, integration presupposes an active mode of operation *during* research. A model of interdisciplinary research strategies is put forth, emphasizing the accumulative and hierarchical relation between the epistemic factors, in order to cope with these epistemic challenges.

Research status

Occasionally, debates over archaeology´s true identity get raised. One such debate has been promoted by Andrew Jones, claiming there are two basic approaches to archaeology: A humanistic and a scientific, and that this dualism is problematic because all archaeologists, no matter their theoretical affiliations, share the same phenomena of study – that is, material culture (Jones 2001, 2004:329, 2013; Gibbon 1984:92; cf. Driver 2004). Jones´ worry echoes

that of C. P. Snow (Snow and Collini 1993 [1963], 2012 [1959]; cf. Kimball 1994:10) and the "two cultures" debate of the 1960s, whereby a breakdown was postulated in the communication between the sciences and humanities – a debate going back to the 1880s *Methodenstreit* of German academia (Brint 2002:212; Menger 1883; Schmoller 1883, 1884). The related "science wars" of the 1990s, did also divide academia along the fault lines of sciences/humanities, this time over the truthfulness and realism of scientific knowledge (Gross and Levitt 1997; Ross 1996; leading up to the Sokal hoax, see Sokal 1996). Putting Jones´ worry over the two cultures in archaeology into the terms of philosophy of science, the risk of such a dualistic condition is *incompatibility* between the two ways of doing archaeology. In the long run, the lack of any shared standard for comparison and evaluation of knowledge production may produce what is known as *incommensurability*. In archaeology, the cementation of a dualism between humanistic and scientific orientations has been voiced in terms of already producing epistemologically incompatible approaches (Kristiansen 2004:77, 2014; Preucel 2001:15647; cf. Boivin 2005:177; Burdukiewicz 2006; Dark 1992). Furthermore, it has been claimed that the real problem facing archaeological interdisciplinarity is the inefficient communication between the two cultures (Lidén and Eriksson 2013:12). Some studies suggest a patterning in the publication of archaeological papers, speaking in favor of practices specific to either side of the science/humanities-divide (Marriner 2009), but further empirical investigations are needed in order to ascertain this correlation (such a bibliometric pattern is substantiated in general academic publishing, see Fanelli 2010; Larivière et al. 2009; Leydesdorff et al. 2011).

Critics have responded to such claims, maintaining that there are no factual basis for invoking a chasm between interpretive theory and scientific methodologies in archaeology, questioning the very divide between archaeological theory and archaeological science (Killick 2005:186, 188; cf. Trigger 1998:1). When considering the relationship between different sections of archaeology, parts of the archaeological community may respond in a dismissive manner to the significance of the two cultures-thesis, claiming that the actual problem facing integration between archaeology and archaeometry is the lack of critical self-reflection awarded this relation. In such a view, the "third science revolution" (Kristiansen 2014) may come across more as a reinstatement of the processual program than a revolution (cf. Chilton 2014:38). In such a case, the problem may not be the current incompleteness of the archaeology/archaeometry-integration, but instead be the very premises of such an integration in the first place. As many archaeologists are without scientific training, some find

that the current enthusiasm of implementing natural scientific methods with archaeology may not be as well scrutinized and subjected to the same standards of critical review in the archaeological community when synthesizing the results (Prescott 2013b:53).

Archaeology has witnessed an unprecedented growth in the application of natural and formal scientific methods over the last three decades (Lidén & Eriksson 2013:18; Killick 2015; Kristiansen 2011:74; Torrence et al. 2015; e.g. series edited by Eerkens; Wagner et al.). These invaluable advances has mainly come from the technical domain, arguably leaving the analytic framework of archaeology sub-optimally adapted to the task of incorporating such new, technical results (Bednarik 1996; for a similar argument provided by the case of simulation in archaeology, see McGlade 2014). This might have unintended consequences for the epistemic *stringency* and *coherence* of the archaeology/archaeometry-relation, because the recent uptake of scientific methods potentially preempts the epistemological groundwork needed in order to integrate the results of such methods with the goals and aims of archaeological research (Naumann 2014:6). Interdisciplinary integration ought to benefit from an inclusion of the theoretical/analytic level. As such, an unprecedented growth in the technical domain may have limited value unless there are theoretical guidelines providing sensible implementation, as well as meaningful application (Huvila 2014:48; Jones 2004:335; cf. Clarke 1978b:465-6). This has been recognized by funding agencies, making interdisciplinarity a vital requirement in achieving funding at both the national and international level (ERC 2015; Langfeldt & Røste 2009:68; National Institutes of Health 2014; cf. Catney and Lerner 2009:290).

I now present the backdrop of the case in which the four epistemological factors are observable. The case also provides archaeological examples throughout the further discussion, being an instance of general difficulties in the epistemology of interdisciplinarity integration between science and archaeology.

Case: Diet of the Mesolithic/Neolithic-transition in Northern Europe

The transition between the Mesolithic and the Neolithic was marked by the invention and spread of agriculture, bringing along a constellation of radical changes to the human condition in the Middle East and Europe between 10.000-4000 BC, such as: Sedentism, cultivation (Weiss et al. 2006), domestication of livestock (Troy et al. 2001), massive displacement of people (Bentley 2013; Haak et al. 2015), the spread of new material horizons (as by the LBK, TRB, BBC and Corded Ware), homogenization of cultural practices

(Eriksson and Lidén 2013:296), expanding trading networks (Thorpe 1999:25), influx of diseases and degeneration of health (Halcrow et al. 2013), social stratification and the establishment of political power centers (Powers and Lehmann 2014), and a general population growth (Bocquet-Appel 2011; Shennan et al. 2013). Recent aDNA studies also suggest that the genetic make up of Mesolithic people are unconnected to modern populations, supporting the claim that the displacement of local hunter-gatherers by the migrating farmers eventually became total, without significant intermingling (Lazaridis et al. 2014).

Of most interest to us here, is the revolution in diet following the transition to the Neolithic. It has long been postulated that farming and husbandry would make significant changes to the dietary composition of Neolithic people (cf. Richards 2002). Still, the rate of dietary change and its significance has been uncertain, to the point of some questioning the very concept of a dietary shift (Borić et al. 2004). The increasing precision and affordability of archaeometric methods such as stable isotope analysis, DNA sequencing and radiometric dating, promises to alleviate such uncertainty. An ongoing debate between two research teams, one conducting stable isotope analysis, and one conducting faunal analysis, has arrived at opposing conclusions regarding the impact of the Neolithic transition on prehistoric diet (Richards and Schulting 2006): The isotopic data suggest a rapid and clear cut transition from a heavily marine-based diet in the Mesolithic, to an almost exclusively terrestrial diet in the Neolithic (Richards et al. 2003). The faunal data on the other hand suggest a continued importance of marine foodstuffs with a gradual uptake of a terrestrial diet in the long run (Bailey and Milner 2002; Milner et al. 2004). This demonstrates that integrating results of different methods are inherently difficult. In this case, the results of methods often used for internal calibration seems to oppose one another, and points to the importance of archaeological/culture historical synthesis in order to make sense of the opposing results.

In general there are two possible outcomes (weak and strong) of a situation where multiple (and opposing) theories exist to explain the same phenomena/data set: 1) The weak case might be settled by a mere choice between opposing theories, based on a set of predetermined criteria for selection, such as its continuity with an established knowledge base, theoretical economy, logical stringency, or even aesthetics. In this case, a candidate theory is chosen at the expense of others, resulting in the refutation of the not selected ones. 2) In the strong case, a fusion of several proposed explanations might occur in the case of them not being fundamentally exclusive, but rather exhibiting explanatory power over

different parts of a single phenomena. This is known as integration.

Regarding diet of the Mesolithic/Neolithic transition, the problem of incompatible results has been formulated as follows: "If the stable isotope data is accepted as showing a terrestrial based diet we need to ask other sorts of questions which may help us explore why the zooarchaeological and stable isotope data sets appear to be opposed: [...] why does so much marine food waste occur and yet not show up in the stable isotopes?" (Milner et al. 2006:457). There may be many factors influencing this result, making them seem incompatible, but it is likely that the incompatibility stems from the lack of bridging knowledge and a bigger picture integrating them.

In the further proceedings of the paper, I aim at giving some epistemological answers to the question of why the archaeometric methods seem to produce opposing results, and propose that a further understanding of *interdisciplinary collaboration* in archaeology is helpful in dealing with such difficulties. The case will provide examples during the discussion of the four epistemic factors affecting interdisciplinary cooperation mentioned in the introduction. The above is meant as a backdrop for what is essentially a discussion of the general properties of interdisciplinary collaboration in archaeology and archaeometry, which we now turn to.

Interdisciplinarity and its challenges

A multitude of definitions exist to accommodate the many varieties of multi-, inter- and trans-disciplinarity. Still, their main purpose is combining practitioners of different academic disciplines in the pursuit of a common goal, be it a research problem, technical development or standardization of tools and concepts across study areas. The terms are often used interchangeably (Choi and Pak 2006:224), but a distinction is made in accordance with the rate of cooperation and integration between the participant disciplines: *Multidisciplinarity* represents a weak form of integration, in that the different disciplines maintain their integrity throughout the project whereby they combine different expertise in order to solve a common problem. *Interdisciplinarity* represent a strong integration of different disciplines, whereby a merging of concepts and methods produces a more stable and coherent approach, which goes beyond the normal range of the participant disciplines (cf. Choi and Pak 2006). Furthermore, multidisciplinary research often gets published in a range of journals specific to the different disciplines participating in the project, while interdisciplinary research generates novel results in the intersection between the respective disciplines, which is more often published in

journals dedicated to pioneering research.

The main premise promoting interdisciplinarity is the idea that a constellation of researchers of complementary expertise provides a wider range of skills more suitable for solving increasingly complex problems. The broader the expertise of the research group, the more factors influencing the phenomena of interest are potentially fathomable and can thus be made explicit. The *Australian Council of Learned Academies´* extensive research on interdisciplinarity puts it this way: "The real world does not always present its problems and opportunities conveniently aligned with traditional academic disciplines so mechanisms are needed to facilitate interactions and collaborations between researchers working in widely different fields" (Webber 2013:10; cf. Bammer 2012). This corresponds well with the empirical situation facing archaeology, and the discipline has from its very beginning maintained an open dialogue with the natural sciences (e.g. the Kitchen Midden Commission, see Madsen et al. 1900; cf. Judson 1961; Tite 1970). Even so, some studies suggest that the negative effects of cross-disciplinary cooperation can outweigh the desirable effects (on the effects of personal factors, see Ancona and Caldwell 1992; for the effect on quality versus quantity of output, see Fay et al. 2006). Assessing the factors affecting interdisciplinary outcomes thus become a matter of importance.

General factors affecting the outcome of interdisciplinarity

Previous research have already identified some of the factors influencing the outcome of interdisciplinary research (Martin 2013:4,8; Nissani 1997). What seems to be most important to the success of such collaboration, is the establishment of "high quality team processes, characterized by the pursuit of a shared vision, high interaction frequency, trust and reflexivity" (Fay 2005:555). Self-reflexivity within cross-disciplinary research is emphasized (Dreu 2002). It is beneficial that the group repeatedly reflects upon its own practice and goal achievement, as it improves the quality of cooperation and integration between experts by stringing out the work processes, and thereby making common points of reference.

A shared vision and high interaction frequency amongst the partitions has been identified as providing the necessary integration and 'glue' in research groups (Fay et al. 2006:564). Still, for a shared vision to be effective in organizing research groups, the participants have to identify with the vision to an extent that overcomes the allegiance to their discipline of origin, which has been internalized during training and practice. Studies have proven this to be difficult (Brown et al. 2000; Psychol et al. 1997; cf. Lang 1982). A range of

factors affecting the outcome of interdisciplinary collaboration has been identified by the Mental Health Commission´s (2006:16-18) general review, and by the conference "Learning by doing – making interdisciplinarity work" (Martin 2013):

- Management structures should be clearly defined as "the effectiveness of teams is limited unless they have a clear role and position in the organisational structure of the service" (cf. Harris and Beyerlein 2003).
- Balancing general and specific professional roles by clearly defining the complementarity of different expertise.
- Effective conflict resolution, by way of hierarchical decision-making in order to maintain a unified vision whereby dissenting views or unequal emphasizing of aspects gets coordinated. For this to work without enhancing conflict, a general atmosphere of trust and friendliness must be in place (see Edmondson et al. 2001 on the importance of trust as a success factor).
- The training of participants in multidisciplinary cooperation as a skill of its own.
- The implementation of a single shared system of record keeping which simplifies the sharing of information and inter-group communication.
- Once in place, development of multidisciplinary group cannot be left to it self. Active maintenance and repeated self-reflexivity on the cooperation and integration of the group is important in order to maintain focus and coherence (cf. Marzano et al. 2006).

Rather than these factors having either a positive or negative effect on the integration of interdisciplinary research, the outcome of the individual factors is mostly a function of the processes in which they are incorporated. They may therefore contribute both to desirable and undesirable outcomes, depending on the uses they are put to. In archaeology, there are several factors that might challenge the successful integration of interdisciplinary research. Amongst them are the level of competence in related fields – the limited training in natural and formal sciences of archaeologists being frequently nominated (Jones 2013:23; Kristiansen 2014; Prescott 2013b:43; Shennan 2013:46). The matter of individual competence is a prime factor effecting the sustainability of archaeometric integration with archaeology in the long run. This is because an important part of sustainable cooperation requires the training of multidisciplinary archaeologists (in person), rather than merely collecting individual specialists in a common research project.

Other organizational and financial factors have been identified as challenging archaeology´s cooperation with the sciences, such as communication (Levy 2007; Venclová 2007), lack of funding for interdisciplinary projects (Gómez-Gómez and Hochberg 2014:135), the unattractiveness of positions in archaeological science compared to dedicated research in the scientists own field, jurisdictional constraints (e.g. national heritage regulations and indigenous rights) (cf. Prescott 2014:139), as well as the practical difficulties of combining and directing complex research projects with participants of different training and personal qualities (Dincauze 2000:23). Being able to deal with all these factors on a daily basis are of importance to the manager of interdisciplinary archaeological projects. Notwithstanding the importance of understanding how to cope with these factors, this paper takes on a different agenda – in trying to identify and understand some of the main *epistemological* challenges.

The epistemology of interdisciplinary collaboration

In the following I account for some of the epistemic factors that potentially affect the outcome of interdisciplinary collaboration between archaeology and archaeometry. The identification of epistemic factors made in this paper is is only meant as an initial mapping, and I say nothing of their prevalence within archaeological practice. Instead, the purpose is to explicate what I claim is an under-examined part of the foundations of archaeological practice. I focus on four factors: 1) Communication, 2) specialization, 3) explanatory ideals, 4) uncertainty levels and types.

Though it certainly would be possible to include a whole range of factors, a selection has been made in trying to cover a specter of epistemic challenges, each being successively more fundamental. As the factors build on each other, I suggest they should be examined in conjunction. It is worth mentioning that scale-related problems are not included here, due to being thoroughly addressed elsewhere (Stein 1993; see contributions in Lock and Molyneaux 2006 and Robb and Pauketat 2013). The listed factors are understood as epistemic, in relating to the abstract properties of knowledge. Epistemological challenges are different to other categories of potential challenges, such as practical and methodological ones, in that they concern the meta-theoretical and analytic level of knowledge production (on the epistemic division of labor between disciplines and scientists, see Weisberg and Muldoon 2009).[1]

1 For an epistemic inquiry to be of relevance to archaeology, one must assume that archaeology relates to knowledge and the aim of truth. Archaeologists might be unaccustomed to explicitly cite the epistemic definition of knowledge as "justified true belief", when describing the intended outcome of archaeological

Communication and mutual understanding

The integration of methods, as well as that of disciplines, is highly dependent on communication. The key to interdisciplinarity cooperation therefore consist in securing coherent and efficient communication. As specialists of different fields come together in research groups, problems of terminology may arise even in the collaboration between closely related disciplines. This is because "scientists speak in dialects that are specialized to their disciplines [...] The fundamental challenge to interdisciplinary communication is the different ways we see the world, that is our constitutive metaphors. The greater the divergence between these foundations, the more difficult it is for communication to be effective" (Wear 1999:299-301). Though the world view-hypothesis presented in this quote may seem a bit exaggerated, it points to the vital part played by language in research, in the form of terminology. This becomes particularly evident when articulating research problems. As research problems are formulated, they also take on the role of guiding our attention and efforts within the parameters set by the very statement itself (cf. Davidson 1984). This is necessarily the function of a research statement, but it might have serious implications for the cooperation of disciplines with more or less congruent terminologies. Archaeology, seeking to understand historical processes including self-conscious subjects, may potentially find it difficult to communicate with the natural sciences, they being directed at inert matter and natural processes. They also describe events in terms of causation, compared to the archaeological terminology of intentionality. In addition the scale of time and events are potentially quite different.

Furthermore, in interdisciplinary cooperation even small differences in the *conceptualization* of objects/phenomena/events may cause confusion and misunderstanding. At an even more minute level, there might occur differences in the *application* of shared concepts. Even when agreeing on the definition of some concept, its practical application may end in slight variation due to different training and former experience with its utilization. As language is the medium of interaction and knowledge sharing between the participants, making the most out of the communicative interactions has continued importance. Language-related problems may arise at all stages of interdisciplinary collaboration, and turn an

conduct. Still, the kind of knowledge of interest to archaeology (and the other sciences) is propositional knowledge ("knowledge that"), which aims at establishing the conditions that are necessary and sufficient for a connection to be made between the knowing subject and a given proposition (cf. Fantl 2014; Ichikawa and Steup 2014). When defining the four challenges as epistemic, it follows that they somehow impede the correspondence between our perceptions of the past, and the past as it was.

otherwise brilliant project (in its individual components), into an unproductive whole. Intercommunication thereby provides the medium by which the individual elements gets aggregated into a unified whole.

It is worth noting the particular language-related responsibilities of archaeologists in interdisciplinary research, as it is we who often manage such projects. In order to manage projects consisting of various fields of science, "archaeologists *have to* communicate with researchers from other disciplines in a qualified manner. An important prerequisite for such communication is of course having knowledge about the premises, concepts and traditions of other disciplines – as a common understanding is needed to be able to talk to each other. The basis for mastering this language is thus a minimum of knowledge, and with few exceptions, it is the archaeologists who must acquire this knowledge" (Prescott 2013a:53; cf. Prescott 2013b:40 – my translation).

It follows then, that the efficiency of intercommunication between disciplines, or sub-fields within archaeology, is very much an effect of the understanding one has of the other disciplines. An example of this pertaining to the science/humanities-divide in archaeology, is the perception that the contribution made by the natural sciences to archaeology comes mainly in the form of methods and techniques (cf. Bintliff 1979:68; Henderson 2001:1). An indicator of this might be seen by the *AIA´s Pomerance Award for Scientific Contributions to Archaeology*, which has mainly been awarded to technical advances. A closer examination will show that the technical contributions may not constitute the whole picture. Though being awarded less attention, the theoretical imports are of equal significance to the functioning of modern archaeology (in the form of evolutionary theory, taphonomy, stratigraphy, chronology, trophic ecology, statistics, formation processes and simulation to name a few) (Codding and Bird 2015; Martinón-Torres and Killick 2015). This tendency to depreciate the contributions made by natural sciences of their theoretical features has been identified as an important factor inhibiting fruitful cooperation with the sciences (Prescott 2013a:55; cf. Cremeens & Hart 1995:16; Dincauze 2000:21; Hardesty 1980:161). The appreciation of scientific results as *atheoretical* is problematic because it may result in a lack of a common analytic framework in which the results of different methods may be integrated with the research questions concerning archaeology. As different methods may be at odds with each other, taking their results at face value may cause incoherence when synthesizing the results (which are of main interest to the archaeologist), if their theoretical implications are not taken into account (Hardesty 1980:161).

Similar communicative problems may be identified when returning to the case. There are some apparent misunderstandings, such as "We certainly did not attempt" (Milner et al. 2006:456) and in making the other party responsible for the incompatible results by statements such as "Again, there is a tendency to overlook biases in their own data" (Ricards and Schulting 2006:447). A major factor causing difficult communication between the archaeometric methods of the case, is the lack of a mutual understanding of the culture historical processes that might bring about such apparently opposing results. In the end, the opposing results of archaeometric methods may only be given an interpretive frame of reference by way of archaeological explanations. The dispute in this case is therefore much concerned with what historical processes might produce such a material record. A taboo not to utilize marine resources has been suggested in favor for an abrupt dietary change (Richards 2003; Thomas 2003), while others ascribe the opposition to other factors than the actual diet, such as geographical diverse settlement patterns and methodological biases (Bailey and Milner 2002; Lidén et al. 2004; Parkington 1991; Sealy and van der Merwe 1992).

Also, there is no agreement between the parties on whether the results are in fact incompatible: "the continued occasional use of marine resources in the Neolithic *is not at all incompatible* with the isotope data, but is largely *irrelevant* in the overall question of large-scale dietary shifts" (Ricards and Schulting 2006:445 – my emphasis). A common understanding of the level of scale and area of applicability of the other party´s method might enhance compatibility.

The paradox of integrating specialized disciplines

Even in cases of well-functioning intercommunication, whereby discipline-specific terminology has been clearly defined and made compatible, there still exist more basic structural challenges to epistemic integration, which the following argument illustrates:

P1) Promoting the accumulation of knowledge requires specialization.
P2) The accumulation of knowledge is in turn potentially hindered by fragmented specialization – that is, the lack of coordination and synthesizing of specialized knowledge.
P3) Interdisciplinarity becomes necessary in order for the accumulation not to be hindered by the dividing lines of specific disciplines.
Q - paradox) Interdisciplinarity may be prevented by the degree of specialization achieved initially by the individual disciplines, as the aim of interdisciplinary is synthetic and general,

thereby having to overcome the specialization of disciplines when integrating them.

As a result of this counterintuitive condition, highly specialized fields of knowledge may be *less* susceptible to interdisciplinary integration, due to a more developed structure of operation, consisting of terminology, methodology and epistemics specifically adapted to the discipline. Conversely, it might be easier to achieve interdisciplinary integration amongst less specialized disciplines, due to fewer terminological, methodological and epistemic strictures. This is of relevance to the interdisciplinary integration of archaeology and archaeometry, as the natural sciences are more specialized then archaeology. In an archaeological project, the more humanistic elements of the research (say culture-history interpretation), are more amendable to the specialized archaeometric methods, then the other way around. The unequal degree of specialization along the two cultures-spectrum affects archaoelogy/ archaeometry-cooperation in such a manner that the more specialized an archaeometric method is, the fewer areas of potential application it may have, and the easier it will take on the role of an unintegrated supporting science. Simultaneously the more precise its data is going to be.

The dietary case is indicative of this relation: The archaeological application of isotope and faunal analysis has become increasingly specialized, providing data of growing precision. With it, a growing trust has been placed in the archaeometric results, corresponding to a need for archaeological reinterpretation of old topics – which was also the case in the Mesolithic/Neolithic diet case study (Milner et al. 2006:10). The archaeometric methods have become common tools in archaeological investigations of diet and subsistence. Even so, archaeometric analyzes are often performed at separate laboratories, paid for by archaeologists awaiting the results in order to integrate them in field reports and publications. Though some interdisciplinary archaeology departments do exist, this is not the norm, which might make the two-way communication flow less freely between the specialized sciences and archaeology (arguably the case for dating services). Furthermore, a growing inequality in the access to archaeological science services has been pointed out (Killick 2015:246).

The paradox of specialization only points to the formal properties of the potential integration amongst different disciplines. As such, the relation does not hold when it comes to assessing parameters such as success rate, output efficiency and quality of production. Quite to the contrary, the more specialized and developed the discipline/method, the more coherent and precise are the contents of its knowledge production going to be. Advanced specialization facilitates a more secure exchange of knowledge between disciplines (even if being very

different), as higher degrees of operationalization in analytic, methodological and theoretical units may result in qualitatively more fruitful integration. This relation might very well be the result of highly specialized disciplines working within well defined and demarcated areas of inquiry, while less specialized disciplines are prone to thematic and methodological overlap.

I follows then, that the paradoxical relation might also hold when it comes to the epistemological integratability of disciplines. Closely related disciplines (e.g. amongst the humanities and social sciences) exhibit extensive overlap of research areas, which facilitates the natural development of related terminology and concepts. Still, such relatedness does not in it self have to promote epistemic integratability. In fact the opposite might turn out to be the case most often. This follows from the competitiveness and multiple developmental trajectories of closely related disciplines. Combining otherwise related disciplines that employ opposing models regarding the phenomena of interest may turn out more impairing to the overall integration, then combining very different disciplines of unrelated descent. For example, combining the thematically overlapping disciplines of sociology and economics may prove fundamentally problematic due to their opposing assumptions on the nature of social processes – which in turn affect what methods of study and what explanations are thought appropriate. On the other hand, combining art history and conservation chemistry, there are few epistemic reasons that might make these disciplines disagree over founding premises. Instead, what might be expected is the difficulty of a true interdisciplinary integration taking place, as research projects combining them are likely to be spearheaded by only one discipline at the time with the other discipline acting as support – an experience made by similar projects (Streeton 2014). Archaeology may experience both scenarios, depending on the nature of the collaborative project. Though similar in many respects, one might expect the terminological and thematic overlap with other humanistic and social sciences to produce some difficulties for the epistemic integration, while archaeological cooperating with natural sciences might find it difficult to engage in a two-way integration.

What seems to result from this analysis is that the initial specialization of disciplines preferably should be taken into account if the efficiency and well-functioning of interdisciplinary cooperation is to be enhanced. Measures should be put forward in order to facilitate coherent collaboration which help overcome the differences of specific disciplines. This is particularly important to keep in mind for the collaboration between archaeology and the sciences, due to their very different levels of specialization.

Material properties and corresponding explanations

Combining disciplines with different sets of empirical data, each consisting of specific properties, is potentially problematic at a fundamental level. The epistemic reason for this is that disciplines of different empirical evidence tend to adhere to contrasting explanatory ambitions. This is true even in cases where disciplines share a common data source, as is quite common in the humanities and social sciences.

As disciplines gets specialized over time, they do so in pursuing different areas of knowledge and in trying to answer different types of questions. By a rough categorization, a distinction can be made between research wanting to answer the question words of 1) what/how, and 2) why. A traditional division is made between fields of inquiry aiming at causal *explanation* and those aimed at hermeneutic *interpretation* of phenomena – the former corresponding to the harder sciences, and the latter to the humanities. The history of science and the "two cultures"-debate provides many reasons for this separation, which will not be given here (see Comte 1848; Snow and Collini 1993, 2012; Weber 1949; for the origin of the divide; see Ramberg and Gjesdal 2014). The point is that a particular problem may arise from integrating scientific methods with archaeology, which is the *hierarchization* of results on the basis of their explanatory affiliation (cf. Gosden 2005:183). For example: When archaeology collaborates with practitioners of the natural sciences, the results of the scientific investigations are generally aimed at clarifying some element of uncertainty connected to "how" and "what" types of questions – *how* did the diet affect this individual´s health, *what* was the paleoenvironment like etc. When the scientific results are to be incorporated into an archaeological frame of reference, they are likely to be ascribed a static position within the interpretive hierarchy that makes up the answer to an archaeological research statement. This happens because the argumentative build up of this interpretive hierarchy mostly starts of with factual descriptions (or theories) provided by supporting sciences, and moves up towards general statements regarding prehistory – abstraction and uncertainty increasing along the way upwards (Needham 2005:193; cf. Hawkes 1954). It is beyond the scope to discuss whether there are any reasonable alternatives to this structure, though it poses some interesting challenges to the epistemic coherence of archaeological interdisciplinarity.

The challenge consists in the very relation between the different elements included in the overall argument. If proper interdisciplinary integration is to be achieved, ascribing a static position to certain elements is likely to be insufficient. Instead, repeated adjustments should be made to the research statements and the working processes of the entire group, in

order to ensure relevance on all parts. The very formulation of research statements are equally important in narrowing down the amount of potential hypotheses belonging to a set of data, as the actual application of methods. This is because the active process of observation is a direct result of the restrictions imposed by the research statement, to which the methodology is only but a means to an end (Boivin 2001:259; 2004:177; cf. Golinski 1998:133; Hacking 1983:190). Still, whatever precision the archaeometric methods may achieve, they may not solve archaeological problems by themselves. Archaeometric methods may be able to confirm/disprove archaeological observations with greater precision than previously possible, but only after the observations have been made and recognized as legitimate empirical observations. The occurrence of real relevance is only made possible through fruitful integration of archaeometric results with well formulated archaeological questions. Furthermore, integration proper may only occur if this relation is reciprocal.

This is also evident in the dietary case. The material properties belonging to the two methods are significantly different, consisting of zooarchaeological assemblages at archaeological sites, and collagen and apatite extracted from human teeth and bones of prehistoric individuals (cf. Harrison and Katzenberg 2003). There should be no significant differences among the archaeometric methods with respect to explanatory ideals, though some differences in the methods´ scale and area of applicability has already been noted. The difference occurs when compared to the overall archaeological ambition of explaining dietary choices and adaptations in the past. Both stable isotope analysis, faunal analysis and archaeology utilizes the archaeological record. Still, the archaeometric methods aim at true/probable descriptions of the materials themselves, while the goal of understanding the cultural formation processes of the remains are inherently archaeological. If granting perfect representativeness of the isotope and faunal results, they may still only provide archaeology with factual data that are in need of historical context and explanation. The *hierarchization* of results on the basis of their explanatory affiliation is evident by archaeometric data providing a base for the archaeological interpretation of the past.

The specific properties of the empirical evidence of different disciplines, as well as the different explanatory ambitions regarding the evidence, is fundamentally affected by the type of uncertainty connected to it – to be explored below.

Integrating different levels and types of uncertainty

A significant epistemic problem is related to the collaboration between disciplines who 1) are dealing with qualitatively different types of uncertainty, which result in 2) varying spaces of uncertainty. This factor will be granted most attention, as it is considered to be spcifically important to the collaboration between archaeology and archaeometry, and at the same time the least explored (for one exception on the epistemic uncertainty in archaeology, see Gero 2007).

The space of uncertainty (SoU)

The amount of possible statements regarding archaeological entities such as objects, dates, settlements etc., are limited and determined by the properties of the empirical evidence. More precisely, it is so by virtue of the physical properties of archaeological materials having specific mass and extension, making archaeological claims have a given truth value (true or false. An object-based data set makes it inconceivable that contradictory statements are true simultaneously. Still, confirmation of archaeological hypotheses and explanations is difficult.

In claiming that archaeological statements (regarding physical entities) always exhibit a given truth value, it is only correct in a logical and epistemic sense, but is most often far from achievable in practice. It is therefore common to speak of "interpretations" of archaeological entities as no consensus prevails on whether archaeology is able to produce true statements concerning the past. A common objection to the truthfulness of archaeological entities is that uncovering the true characteristics of individual objects (e.g. by archaeometric means) is one thing, while it is quite another to apply these (scientific) facts about the micro level to underpin properties of the macro level of archaeological reasoning. The tension rises as there is no 1/1-relation between the material properties at the micro level, and archaeology ´s ambition to empirically demonstrate inferences about macroscopic prehistoric phenomena. What is often a humanistic ambition to go beyond the information of mere objects in order to gain insight into past states of affairs, requires inferences that cannot be directly deduced from the micro properties of archaeological objects provided by archaeometric methods (cf. Hawkes 1954). This tension produces what might be called «the space of uncertainty» (henceforth SoU). This space denotes the quantity of potential inferences that can be made in the transition from empirical evidence and archaeometric data, to archaeological explanatory statements. Two categories of uncertainty can be identified as producing the properties of the (SoU):

A Priori uncertainty (au)

The *a priori* impossibility of recreating the past forces the archaeologist to reconstruct whatever small sections are available through the limited empirical record. This reconstruction is made by drawing inferences from the material remains to the immaterial and unobservable events they are to represent. This move from data to explanation however, is not arbitrary as the information value of the data set determines and limits what questions can be given appropriate answers, and by its very being, excludes a whole range of potential queries. As such, some potential knowledge will always be beyond actual epistemic reach. For example, one may never acquire accurate knowledge regarding first-person qualia from a material data set, no matter its resolution and representativeness. Such inherent uncertainty, as held by archaeological entities, is termed *a priori* uncertainty, and it may get expressed in two separate forms in the archaeological record.

Firstly, there is the epistemic exclusion of past phenomenon that have no material expression – in the sense of not being represented by any available evidence, which is a no-data situation. Secondly, and of more interest to us here, are the cases of mutual enabling and exclusion of research questions. This situation is universal, and applies to all engagement with archaeological materials. As noted above, only some of the potential knowledge regarding some objects/phenomena etc. does ever become actualized. What gets actualized depends on several factors, of which the methodological finesse and the design of current research strategies are important (cf. Kuhn 2012:24). The current enthusiasm over the third science revolution and general increase of scientific methodologies in archaeology, reflects the hope that archaeometry may widen the potential set of answerable queries of the past, and at the same time reduce the space of uncertainty regarding long-standing debates in archaeology. This has been the case several times over, as aDNA reopens the subject of migration/diffusion and ethnicity (e.g. Gao et al. 2015), geochemistry reopens debates on archaeometallurgical and geoarchaeological provenience (e.g. Bray and Pollard 2012) and stable isotopes and lipid residue analysis add new insights into diet, subsistence and seasonality, as seen by the dietary change of the Mesolithic/Neolithic-transition.

Self-induced uncertainty (su)

In addition to the irreversible *a priori* uncertainty, all archaeological reasoning are exposed to differing levels of *self-induced* uncertainty. As there is a possibility of multiple descriptions accounting for the same set of data, one is never able to include all contributory factors. This

even goes for the ideal case of perfect information, as theory choice seems to have some time-indexed properties which enables a fundamental discord amongst competing world views (Acuña and Dieks 2014; cf. Laudan and Leplin 1991), as well as more localized effects of academic history and paradigmatic implications (Kuhn 2012:94; Popper 2002:92). In real life situations though, a whole range of self-induced uncertainty factors are likely to effect all research: For instance, the very focus laid down by the research statement, preferential emphasis put on certain variables, practical and economical obstacles, lack of time, direct misinterpretations, incorrect calibration of equipment, personal agendas etc., all contribute to making less than optimal conditions. In short, all factors that goes into real life efforts at knowledge production, does also contribute to at least some level of self-induced uncertainty. Self-induced uncertainty in the research process is therefore understood as every action that in some way does *not* contribute to a reduction of the number of potential inferences to be made from the material data set, unless they can be traced back to properties of the objects themselves.

As long as there is a high probability that varying inferences can be made between the empirical data and its explanation, the knowledge production of archaeology is going to be prone to uncertainty. When the material data can be cited in support of varying and conflicting claims, and with no established standard for distinguishing correct and incorrect inferences apart, the epistemic limitations imposed by self-induced uncertainty will be substantial. This is what was observable in the case of isotopic and faunal data, which resulted in a space of uncertainty containing multiple possible inferences (without a proper protocol to guide theory choice). Such spaces of uncertainty within archaeological inferences may pose some risk to the veracity of conclusions, as well as to the knowledge base of the discipline in general.

The concept of uncertainty become useful when returning to the case: There are differences in the uncertainties associated with faunal and stable isotope analysis, and I take this difference to be the very root of the discussion. On the one hand, faunal assemblages *directly* testify to the intake and composition of foodstuffs, presented by zooarchaeological remains (especially shellfish in this case). On the other hand, the results of stable isotope analysis provides an *indirect* measure of dietary composition through the identification of an individual´s trophic level. These differences become evident by the words in which the discussion is framed: “The isotopic evidence presents a long-term measure of *lifetime diets*, and clearly shows a significant change in human diet between the Mesolithic and the

Neolithic. Remains of fish and shellfish recovered from archaeological sites are the remains of *individual meals*, but are not indicative of the overall diet of a human population" (Richards and Schulting 2006:445 – my emphasis).

The uncertainty of faunal analysis mainly concerns the representativeness of the assemblage, both in that different foodstuffs produce unequal amounts of waste and their unequal preservative qualities (middens being highly visible due to high preservation and that 700 molluscs are needed to cover the caloric demands of one person per day (Bailey 1975, 1978)). Faunal remains are also unable to provide an adequate picture of the whole range of foodstuffs going into real diets, as only parts of a total diet is discarded and preserved for future discovery. The most uncertain elements of stable isotope analysis are sample size (in this case 32 Mesolithic individuals (Milner et al. 2004:13)), as well as methodological problems relating to camouflage effects of different protein sources (Grupe et al. 2013:154; Hedges and Reynard 2007:1244) and the comparability between geographic areas and individuals (O'Connell et al. 2012; Solomon et al. 2008; Woodcock et al. 2012).

As such, the two methods produce uncertainty at different levels, one being over the material presence in the assemblage, the other over the general validity of its conclusions, as isotope analysis mostly measure the protein intake during the last 10 years of a lifetime. Furthermore, archaeology´s uncertainty is composed of the uncertainty belonging to all its constituent parts. When applying faunal and stable isotope analysis to the study of prehistoric diet, the uncertain elements of the individual methods and concepts, be it aprioric or self-induced, are accumulated into the overall culture-historical argument.

The process of inference

So what might be done about this self-induced uncertainty and the space of uncertainty? In attempting an answer to such difficult matters, I apply some tools provided by philosophical logic. Despite the next section being technical and general as to the logical properties of uncertainty spaces and inference-making, the point is to provide an analysis of the very fundamental epistemological structure of interdisciplinary integration. The results are reviewed in the subsequent discussion below.

Firstly, I assume that uncertainty in archaeological inference processes are reducible through increasing the precision and analytic rigor of the stages composing the archaeological process. Putting this into practice would require establishing a standard for the evaluation of *commensurability* amongst archaeological inference processes, as the internal elements of a

research projects need to be directly comparable. Commensurability refers to the comparability, translatability and compatibility of theoretical claims (Oberheim and Hoyningen-Huene 2013). Within philosophy of science, the purpose of assessing incommensurability between claims is to assess their validity and accuracy, so that one has a rational basis on which to prefer certain claims over others (Kuhn 1977, 1983; cf. Moulines 2000; Niiniluoto 1980; Popper 2002:280). This is particularly relevant when considering interdisciplinary collaboration, since representatives of different disciplines working together, may adhere to different procedures and explanatory ideals, as well as expecting different practical protocols. When describing interdisciplinary collaboration, a model which reduces the comparison of differences to only four potential outcomes, might prove useful for examining the relationship between archaeology and archaeometric methods (table 1):

Table 1. The four possible outcomes of the evaluation of commensurability:
a) Shares both common procedure and common ideal, b) Shares a common procedure, but not common ideal c) Does not share common procedure, but common ideal, d) Shares neither common procedure or common ideal.

Procedure ↓ / Ideal →	Common ideal	Different ideal
Common procedure	a	b
Different procedure	c	d

If interdisciplinary research teams answer to opposing explanatory ideals, their results risk becoming incommensurable and thereby hinder the accumulation of knowledge (Denely 1999:54; cf. Chua, 1986; Weaver and Gioia, 1995). Even amongst practitioners sharing the same explanatory ideal, the procedures for making inferences may vary, thus potentially making their results incommensurable. The commensurability of interdisciplinary research therefore depends on sharing *both* ideals and procedures.

In archaeology, the *analytic* process of making inferences between a set of data and its explanation mirrors the execution of the *practical* process (carried out from field work to the writing of reports and papers). This pairing of both the abstract and practical process may have come about as a result of the dominant empiricist epistemology of archaeology (Darvill 2008a), and the need to approach the data inductively (Darvill 2008b). The order of elements within the combined process of inference and practical conduct can thus be outlined as follows:

$$\mathbf{d} \Rightarrow \mathbf{e} \Rightarrow_1 \mathbf{c} \Rightarrow_2 \mathbf{x} = \mathbf{k}'$$

Where: d = data collection, e = empirical record, c = empirical confirmation, x = explanation, k´ = knowledge (in practical definition). The markings of ($\Rightarrow_1$) and ($\Rightarrow_2$) signifies the first and second inferences of the process. I claim that the properties of the space of uncertainty in specific cases, mainly are the result of $\Rightarrow_1$ and $\Rightarrow_2$. Given the above process, the space of uncertainty can be given the following expression, which in turn allows for the calculation of the degree of uncertainty:

$$\mathbf{(SoU = su \cdot au)}$$

In which: (SoU) = space of uncertainty, (su) = self-induced uncertainty and (au) = *a priori* uncertainty. The values of (su) and (au) are determined by the outcomes of table 1 (a, b, c, d). At any time, one of the four potential outcomes will determine the properties of the space of uncertainty. Put another way: It is the degree of correspondence/consolidation with common explanatory ideals/standards/procedures that determine the size and characteristics of the space of uncertainty. It follows then that low *a priori* uncertainty implies good *potential* access to knowledge, while low self-induced uncertainty implies good *actual* access – given that the *a priori* uncertainty is constant (table 2).

Table 2. Type and amount of uncertainty, and the effect upon access to knowledge.

Type ↓ / Amount →	Low uncertainty	High uncertainty
A priori-uncertainty	*Good potential access*	*Poor potential access*
Self-induced uncertainty	*Good actual access*	*Poor actual access*

In calculating the degree of uncertainty one summarizes (su) and (au). If the level of both types of uncertainty are low, then the uncertainty level of the space of uncertainty will be accordingly low. Note that the *a priori* uncertainty level may approach infinity ($au \rightarrow \infty$), as the availability of knowledge regarding some objects of study can be virtually zero. Which outcome of (table 1 and 2) that actually occurs are context dependent. Even though an interdisciplinary work group may only hold one of the outcomes at a given time, the purpose of integration is working towards the most desirable state of cooperation, whereby both the potential and actual access to knowledge is made greater through a consolidation of processes and explanatory ideals. Furthermore, these four potential outcomes determine what properties (SoU) exhibits at any time. Being able to define the relation between the outcomes and the properties of (SoU), is an important step towards developing a technique that can reduce the

space of uncertainty. To this end I propose the following formula:

$$\mathbf{(p \wedge i) \supset c}$$

Reads as follows: If (p) = process and (i) = ideal corresponds, then (c) = consolidation ensues. It may be interesting to investigate whether ((p ∧ i) ⊃ c), whereby process and ideals are consolidated, may also be a guarantor for best practice. Note that any of (a, b, c, d) could be inserted as variants of the elements (p) and (i) in the formula ((p ∧ i) ⊃ c). In this way we have a logical expression for the comparison of all possible statements, which enables an assessment of commensurability. The properties of these compositions can be examined in a truth table (table 3), where distinct claims may be examined against a standard:

Table 3. Truth table presenting the truth values of the potential variants of the statement (p ∧ i) ⊃ c. ⊤ signifies true, ⊥ signifies false. The outcome is given by the rightmost column. For a conclusion to be true, both constituent parts (the premises) most also be true. The table is only meant for clarification purposes at an epistemological level, as logical expressions enhance the transparency of arguments. No further application is intended.

	p	i	(p ∧ i) ⊃ c
a)	⊤	⊤	⊤
b)	⊤	⊥	⊥
c)	⊥	⊤	⊥
d)	⊥	⊥	⊥

As shown by the truth table, it is only in cases such as (a), when claims share both a common procedure and explanatory ideal, that proper integration can occur. All the other three potential variants testify to a lack of consolidation and integration. Therefore, in any of the cases of (b, c, d), either the procedure, the explanatory ideal or both, diverge with each other or with a given standard. This causes the space of uncertainty to not be kept at its minimum.

Outline of a common epistemic platform

The above excursion into logics may seem to have taken us far from the initial concern of whether there really is a troubled relationship between archaeology and archaeometry, resonating with the general “two cultures” debate of academic disciplines. Rather to the contrary, its purpose has been to illustrate the very basic properties of integration between elements in general. It may then be applied to the instance of integrating scientific methodologies with archaeology. The outcome of the truth table shows that integration may only be attainable when the working procedures and the explanatory ideals of different

disciplines are made compatible. It is my claim that such compatibility in turn, is made possible through a common epistemological platform, acting as a common standard and mediator between more or less humanistic archaeology and the science of archaeometry. Personally I think the lack of such a common platform, evident by the absence of any general debate on archaeological epistemology, is indicative of a somewhat troubled relation between the two cultures of archaeology. People tend to disagree on whether the relationship is troubled or not. For my part, I see an untapped potential for integrating archaeology and archaeometry, irrespective of how troubling the relation might or might not be. I take it that integration is a desirable goal in interdisciplinary collaboration, in its own right. A goal which is preferably made achievable by explicitly taking care of the four epistemological challenges raised earlier in this paper.

The claim of this paper has been that the increasing application and integration of scientific methods in archaeology result in an ever increasing need for a common epistemic platform. I contend that the most fundamental obstacle to the successful integration of science and archaeology lies at the analytic and epistemic level, as it is "crucial for researchers to command the basic theory and assumptions of other special fields and disciplines, in order to evaluate claims for new methods, applications and results" (Dincauze 2000:4). By identifying and discussing four epistemic factors, my aim has been to illustrate some of the difficulties a common epistemic platform must be able to remedy, if archaeology and archaeometry is to be fundamentally integrated. Though it is not my intention to draw up the basis of such a platform, I claim that a common epistemic platform is desirable in itself, as a consensus on what should form the basic epistemic structure of archaeology, is necessary in order to evaluate knowledge production both amongst archaeological sub-fields and when cooperating with the sciences. Ultimately, a common platform, formed on whatever basis, helps counteract incommensurability. Thus, I hold that the dialectics deriving from disagreements do play a constructive and important role in the development of archaeology (cf. Bintliff 2011:8). Even so, a common epistemic platform is taken as a precondition for dialectics to achieve any level of fruitfulness, as one has to agree upon some basic rules of interaction in order for a true dialectic relation between opposing views to arise. I will now make an outline of the proper function and content of the requested epistemic platform:

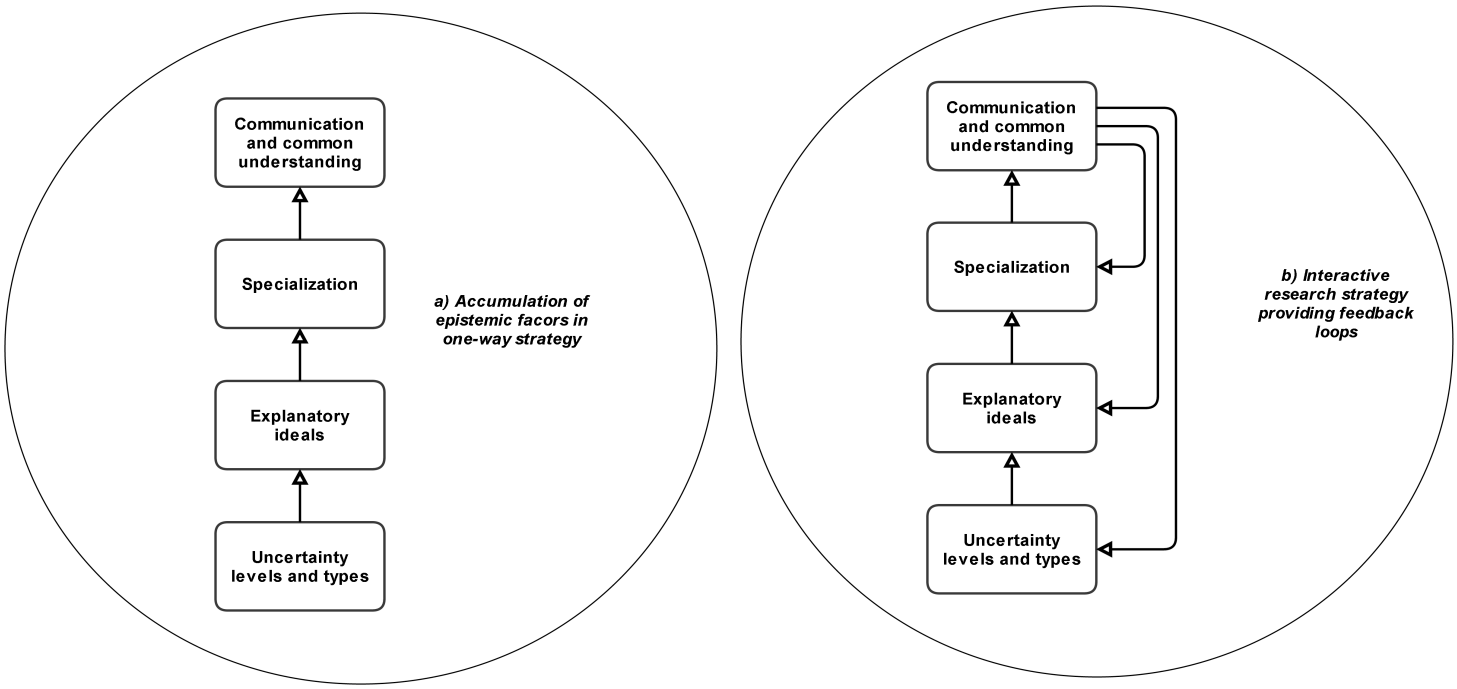
First of all, the function of such a platform would be to provide a unified analytic framework facilitating the consolidation of explanatory ideals and procedures amongst the participants adhering to different parts of the science/humanities-spectrum. This will in turn

make intercommunication safer and easier, while preventing incompatible local dialects to disrupt the functioning of the group.

Secondly, the epistemic platform must also be able to provide a *research strategy* that ensures the highest possible level of relevance to all participants, as "the most eminent question is how to establish team processes that help capitalize on multidisciplinarity" (Fay et al. 2006:565; cf. MHC 2006:6; for a review of how this may be achieved, see Martin 2013:9-10). This may be achieved through a stepwise (bottom up) research strategy whereby the design of every research problem gets influenced by the mutual inclusion of field-specific topics. When turning this essentially practical process into an epistemological consideration, a structure emerges: For interdisciplinarity integration to function properly, it is necessary to build a research strategy that deals with the potential epistemic challenges in a bottom-up manner. By this is meant that each epistemic factor should be dealt with according to their appropriate level, starting of with the most fundamental, and working its way upwards. The reason for this is that risks tend to accumulate if not the most fundamental epistemic challenge is resolved in advance of less fundamental ones. To make an example of the epistemic factors included in this paper: Different levels and types of uncertainty (bottom level) being the most fundamental challenge to coherent integration included here, should be resolved before there is much use in moving on to the next level. It is here asserted that one is not able to consolidate disciplines directed at various explanatory ideals (lower intermediate level) without first clarifying and connecting the space of uncertainty belonging to the participating disciplines. As these factors are handled, one is able to comprehend and thereby make common reference points between disciplines exhibiting different degrees of specialization (upper intermediate level). It is only when all the preceding levels have been accounted for and mended, that the real root of communicative challenges (upper level) may be rectified. This goes to show that what is most often considered the primary challenge to interdisciplinary collaboration (terminology and common understanding), is only but the tip of an epistemic iceberg (see figure 1).

This bottom-up research strategy is very much in keeping with Hawkes´ (1954) ladder of inference, in which – using the terminology of this paper – the more fundamental aspects least prone to uncertainty are addressed first, before moving on to the less certain aspects. It is still important to avoid a situation where the more precise results of archaeometric methods are awarded a static position within the hierarchy of elements going into the overall archaeological ambition.

Figure 1. Model of research strategies not considering (a) and considering (b) epistemological factors affecting interdisciplinary cooperation.



Despite archaeology being a truly multifaceted discipline, the collaboration with other academic fields has often resembled a hierarchical relation, whereby other disciplines get hired according to their ability to provide support in solving specific archaeological needs. A main concern regarding the integratability of scientific methods and research results in archaeology, is that the importation of such elements in many cases does not go beyond the level of a local "pick and choose". This is what the bottom-up research strategy and the common epistemic platform is supposed to counteract: By ensuring multiple points of reference, compatibility can be achieved, thus making sure that every element is included in feedback-loops, re-acting upon the research process itself (cf. Bray and Pollard 2005:180; Jones 2005:206). This needs particular emphasis, as the relation does not only go one way. By facilitating an easier cooperation between archaeology and archaeometry, the common epistemic platform may also enable a more interactive exchange – providing a two-way relation, and making archaeology´s contribution to the sciences more visible: "there are many relationships between archaeology and science. Archaeometry describes only the one-way flow of information and instruments from other sciences into archaeology" (Schiffer 2013).

Conclusion

This paper set out to evaluate what epistemological platform might integrate archaeology and archaeometry in interdisciplinary research projects, and how such a platform might provide productive interdisciplinary research strategies. A model was presented, suggesting how to cope with the cumulative and hierarchical epistemic challenges presented by interdisciplinary cooperation between archaeology and archaeometry. The model proscribes a bottom-up research strategy in which the four epistemic factors consisting of 1) communication, 2) specialization, 3) explanatory ideals and 4) uncertainty levels and types, are included in self-reflexive practice of a research group, integrating the elements in re-active feedback loops. A main objective was applying the epistemological analysis in identifying key factors affecting the "two cultures" relation of archaeology.

When it comes to the very layout of a common epistemological platform, both the practical and the epistemic responsibility of archaeologists heading interdisciplinary research groups has been pointed out: "As definers and integrators of research projects, archaeologists can ease integration with the three *C* goals: *complementarity* of different data sources, *consistency* between data sets, and *congruency* of scale" (Dincauze 2000:24). The latter two goals are particularly important, as they form the basis for a shared epistemic platform. How exactly the three "C goals" are to be achieved is highly dependent on the constellation of people and skills included in a given project. A general rule of thumb may be identified as vital to the proper functioning and successful integration of interdisciplinary research groups: That is the presence of high quality team processes whereby the conceptual schemes and working procedures of the cooperating disciplines gets strung out and dissected into comparable units. This process should be repeated frequently, because as the group reflects on its own practice and goals, it will become more successful in providing itself with common points of reference, thus increasing the quantity and quality of the potential connections between the participants. In essence, this is what integration consists in. It follows then that *integration* is not just the synthesizing of various elements at the *end* of a cross-disciplinary research project, but just as important, integration is an active mode of operation *during* research.

References

Acuña, Pablo, and Dennis Dieks
2014 Another look at empirical equivalence and underdetermination of theory choice. *European Journal for Philosophy of Science* 4(2): 153–180.

Ancona, Deborah Gladstein, and David F. Caldwell
1992 Demography and Design: Predictors of New Product Team Performance. *Organization Science* 3(3): 321–341.

Bailey, G., and N. Milner
2002 Coastal hunter-gatherers and social evolution: marginal or central? *Before Farming, the Archaeology and Anthropology of of Hunther-Gatherers* 3-4: 1–15.

Bednarik, R. G.
1996 Only Time Will Tell: A Review of the Methodology of Direct Rock Art Dating. *Archaeometry* 38(1): 1–13.

Bentley, R. Alexander
2013 Mobility and the diversity of Early Neolithic lives: Isotopic evidence from skeletons. *Journal of Anthropological Archaeology* 32(3). Human bioarchaeology: group identity and individual: 303–312.

Bintliff, J. L.
1979 Archaeological Science: Science and Archaeology, or A Science of Archaeology? In , pp. 68–75.

Bintliff, John, and Mark Pearce (editors).
2011 *The Death of Archaeological Theory?*. Oxbow Books, Oxford, UK ; Oakville, CT, September 15.

Bocquet-Appel, Jean-Pierre
2011 When the World's Population Took Off: The Springboard of the Neolithic Demographic Transition. *Science* 333(6042): 560–561.

Boivin, N.
2005 Comments I: Post-Textual Archaeology and Archaeological Science. *Archaeometry* 47(1): 175–179.

Borić, Dušan, Gisela Grupe, Joris Peters, and Živko Mikić
2004 Is the Mesolithic-Neolithic Subsistence Dichotomy Real? New Stable Isotope Evidence from the Danube Gorges. *European Journal of Archaeology* 7(3): 221–248.

Bray, P. J., and A. M. Pollard
2005 Comments Ii: The Underpinnings and Consequences of the Materiality Approach. *Archaeometry* 47(1): 179–182.
2012 A new interpretative approach to the chemistry of copper-alloy objects: source, recycling and technology. *Antiquity* 86(333): 853–867.

Brint, Steven G.
2002 *The Future of the City of Intellect: The Changing American University*. Stanford University Press.

Brown, Brian, Paul Crawford, and Jurai Darongkamas
2000 Blurred roles and permeable boundaries: the experience of multidisciplinary working in community mental health. *Health & Social Care in the Community* 8(6): 425–435.

Catney, Philip, and David N Lerner
2009 Managing Multidisciplinarity: Lessons from SUBR:IM. *Interdisciplinary Science Reviews* 34(4): 290–308.

Choi, Bernard C. K., and Anita W. P. Pak
2006 Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clinical and Investigative Medicine. Médecine Clinique Et Experimentale* 29(6): 351–364.

Codding, Brian F., and Douglas W. Bird
2015 Behavioral ecology and the future of archaeological science. *Journal of Archaeological Science* 56. Scoping the Future of Archaeological Science: Papers in Honour of Richard Klein: 9–20.

Comte, Auguste
1848 *A General View of Positivism [Discours sur l'Esprit positif 1844]*. Routledge, London.

Dark, Ken
1992 The Science of Archaeology. *Philosophy Now* 3: 21–22.

Darvill, Timothy
2008a Empiricism. *The Concise Oxford Dictionary of Archaeology*. Oxford University Press, Oxford.
2008b Inductivism. *The Concise Oxford Dictionary of Archaeology*. Oxford University Press, Oxford.

Davidson, Donald
1984 On the Very Idea of a Conceptual Scheme. In *Proceedings and Addresses of the American Philosophical Association*, edited by Donald Davidson, 47:pp. 183–198. n/a. Oxford: Oxford University Press.

Dreu, Carsten K. W. De
2002 Team innovation and team effectiveness: The importance of minority dissent and reflexivity. *European Journal of Work and Organizational Psychology* 11(3): 285–298.

Driver, Jonathan
2004 Review of Archaeological Theory and Scientific Practice by Andrew Jones. *Canadian Journal of Archaeology / Journal Canadien d'Archéologie* 28(1): 161–165.

Edmondson, Amy C., Richard M. Bohmer, and Gary P. Pisano
2001 Disrupted Routines: Team Learning and New Technology Implementation in Hospitals. *Administrative Science Quarterly* 46(4): 685–716.

Eerkens, Jelmer (editor).
Interdisciplinary Contributions to Archaeology. Springer.

Embree, Lester
1992 The Future and Past of Metaarchaeology. In *Metaarchaeology*, edited by Lester Embree, pp. 3–50. Boston Studies in the Philosophy of Science 147. Springer Netherlands.

ERC (European Research Counsel)
2015 Accessible at: http://erc.europa.eu/evaluation-panels [Accessed 30.4.2015]

Eriksson, Gunilla, and Kerstin Lidén
2013 Dietary life histories in Stone Age Northern Europe. *Journal of Anthropological Archaeology* 32(3). Human bioarchaeology: group identity and individual LIFE HISTORIES: 288–302.

Fanelli, Daniele
2010 "Positive" Results Increase Down the Hierarchy of the Sciences. *PLoS ONE* 5(4): e10068.

Fantl, Jeremy
2014 Knowledge How. Ed. Edward N. Zalta. *The Stanford Encyclopedia of Philosophy*.

Fay, Doris, Carol Borrill, Ziv Amir, Robert Haward, and Michael A. West
2006 Getting the most out of multidisciplinary teams: A multi-sample study of team innovation in

health care. *Journal of Occupational and Organizational Psychology* 79(4): 553–567.

Gao, Shi-Zhu, Ye Zhang, Dong Wei, Hong-Jie Li, Yong-Bin Zhao, Yin-Qiu Cui, and Hui Zhou
2015 Ancient DNA reveals a migration of the ancient Di-qiang populations into Xinjiang as early as the early Bronze Age. *American Journal of Physical Anthropology* 157(1): 71–80.

Gero, Joan M.
2007 Honoring Ambiguity/Problematizing Certitude. *Journal of Archaeological Method and Theory* 14(3): 311–327.

Gibbon, Guy E.
1984 *Anthropological Archaeology*. First edition. Columbia University Press, New York.

Golinski, Jan
1998 *Making Natural Knowledge*. The University of Chicago Press, Chicago ; London.

Gómez-Gómez, José María, and David Hochberg
2014 Aiming for Transdisciplinary Science: Reflections and Guidelines. *Interdisciplinary Science Reviews* 39(2): 130–142.

Gosden, C.
2005 Comments Iii: Is Science a Foreign Country? *Archaeometry* 47(1): 182–185.

Gross, Paul R., and Norman Levitt
1997 *Higher Superstition: The Academic Left and Its Quarrels with Science*. JHU Press.

Grupe, Gisela, Claus von Carnap-Bornheim, and Cornelia Becker
2013 Rise and Fall of a Medieval Trade Centre: Economic Change from Viking Haithabu to Medieval Schleswig Revealed by Stable Isotope Analysis. *European Journal of Archaeology* 16(1): 137–166.

Haak, Wolfgang, Iosif Lazaridis, Nick Patterson, Nadin Rohland, Swapan Mallick, Bastien Llamas, Guido Brandt, Susanne Nordenfelt, Eadaoin Harney, Kristin Stewardson, Qiaomei Fu, Alissa Mittnik, Eszter Bánffy, Christos Economou, Michael Francken, Susanne Friederich, Rafael Garrido Pena, Fredrik Hallgren, Valery Khartanovich, Aleksandr Khokhlov, Michael Kunst, Pavel Kuznetsov, Harald Meller, Oleg Mochalov, Vayacheslav Moiseyev, Nicole Nicklisch, Sandra L. Pichler, Roberto Risch, Manuel A. Rojo Guerra, Christina Roth, Anna Szécsényi-Nagy, Joachim Wahl, Matthias Meyer, Johannes Krause, Dorcas Brown, David Anthony, Alan Cooper, Kurt Werner Alt, and David Reich
2015 Massive migration from the steppe was a source for Indo-European languages in Europe. *Nature* advance online publication.

Hacking, Ian
1983 *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science*. Cambridge University Press, Cambridge Cambridgeshire ; New York, November 25.

Halcrow, S. E., N. J. Harris, N. Tayles, R. Ikehara-Quebral, and M. Pietrusewsky
2013 From the mouths of babes: Dental caries in infants and children and the intensification of agriculture in mainland Southeast Asia. *American Journal of Physical Anthropology* 150(3): 409–420.

Hardesty, Donald L.
1980 The Use of General Ecological Principles in Archaeology. *Advances in Archaeological Method and Theory* 3: 157–187.

Harris, Cheryl L., and Michael M. Beyerlein
2003 Team-Based Organization Creating an Environment for Team Success. In *International Handbook of Organizational Teamwork and Cooperative Working*, edited by Michael A. West, Dean Tjosvold, and Ken G. Smith, pp. 187–209. John Wiley & Sons Ltd.

Harrison, Roman G, and M. Anne Katzenberg

2003 Paleodiet studies using stable carbon isotopes from bone apatite and collagen: examples from Southern Ontario and San Nicolas Island, California. *Journal of Anthropological Archaeology* 22(3). Bone Chemistry and Bioarchaeology: 227–244.

Hawkes, Christopher
1954 Archeological Theory and Method: Some Suggestions from the Old World. *American Anthropologist* 56(2): 155–168.

Hedges, Robert E. M., and Linda M. Reynard
2007 Nitrogen isotopes and the trophic level of humans in archaeology. *Journal of Archaeological Science* 34(8): 1240–1251.

Henderson, Julian
2001 *The Science and Archaeology of Materials: An Investigation of Inorganic Materials*. Routledge, London; New York, January 22.

Ichikawa, Jonathan Jenkins, and Matthias Steup
2014 The Analysis of Knowledge. Ed. Edward N. Zalta. *The Stanford Encyclopedia of Philosophy*.

Jones, A.
2001 *Archaeological Theory and Scientific Practice | Archaeological theory and methods*. Cambridge University Press.
2004 Archaeometry and materiality: materials-based analysis in theory and practice*. *Archaeometry* 46(3): 327–338.
2005 Reply. *Archaeometry* 47(1): 201–207.

Judson, Sheldon
1961 Perspectives: archaeology and the natural sciences. *American Scientist* 49(3): 410–414.

Killick, D.
2005 Comments Iv: Is There Really a Chasm Between Archaeological Theory and Archaeological Science? *Archaeometry* 47(1): 185–189.

Killick, David
2015 The awkward adolescence of archaeological science. *Journal of Archaeological Science* 56. Scoping the Future of Archaeological Science: Papers in Honour of Richard Klein: 242–247.

Kristiansen, Kristian
2004 Genes versus agents. A discussion of the widening theoretical gap in archaeology. *Archaeological Dialogues* 11(02): 77–99.

Kuhn, Thomas S.
1977 Objectivity, Value Judgment, and Theory Choice. In *The Essential Tension*, pp. 320–39. University of Chicago Press.
1983 Rationality and Theory Choice. *Journal of Philosophy* 80(10): 563–570.
2012 *The Structure of Scientific Revolutions: 50th Anniversary Edition*. Fourth Edition edition. University Of Chicago Press, Chicago ; London.

Lang, C. L.
1982 The resolution of status and ideological conflicts in a community mental health setting. *Psychiatry* 45(2): 159–171.

Larivière, Vincent, Yves Gingras, and Éric Archambault
2009 The decline in the concentration of citations, 1900–2007. *Journal of the American Society for Information Science and Technology* 60(4): 858–862.

Laudan, Larry, and Jarrett Leplin
1991 Empirical Equivalence and Underdetermination. *The Journal of Philosophy* 88(9): 449–472.

Lazaridis, Iosif, Nick Patterson, Alissa Mittnik, Gabriel Renaud, Swapan Mallick, Karola Kirsanow, Peter H. Sudmant, Joshua G. Schraiber, Sergi Castellano, Mark Lipson, Bonnie Berger, Christos Economou, Ruth Bollongino, Qiaomei Fu, Kirsten I. Bos, Susanne Nordenfelt, Heng Li, Cesare de Filippo, Kay Prüfer, Susanna Sawyer, Cosimo Posth, Wolfgang Haak, Fredrik Hallgren, Elin Fornander, Nadin Rohland, Dominique Delsate, Michael Francken, Jean-Michel Guinet, Joachim Wahl, George Ayodo, Hamza A. Babiker, Graciela Bailliet, Elena Balanovska, Oleg Balanovsky, Ramiro Barrantes, Gabriel Bedoya, Haim Ben-Ami, Judit Bene, Fouad Berrada, Claudio M. Bravi, Francesca Brisighelli, George B. J. Busby, Francesco Cali, Mikhail Churnosov, David E. C. Cole, Daniel Corach, Larissa Damba, George van Driem, Stanislav Dryomov, Jean-Michel Dugoujon, Sardana A. Fedorova, Irene Gallego Romero, Marina Gubina, Michael Hammer, Brenna M. Henn, Tor Hervig, Ugur Hodoglugil, Aashish R. Jha, Sena Karachanak-Yankova, Rita Khusainova, Elza Khusnutdinova, Rick Kittles, Toomas Kivisild, William Klitz, Vaidutis Kučinskas, Alena Kushniarevich, Leila Laredj, Sergey Litvinov, Theologos Loukidis, Robert W. Mahley, Béla Melegh, Ene Metspalu, Julio Molina, Joanna Mountain, Klemetti Näkkäläjärvi, Desislava Nesheva, Thomas Nyambo, Ludmila Osipova, Jüri Parik, Fedor Platonov, Olga Posukh, Valentino Romano, Francisco Rothhammer, Igor Rudan, Ruslan Ruizbakiev, Hovhannes Sahakyan, Antti Sajantila, Antonio Salas, Elena B. Starikovskaya, Ayele Tarekegn, Draga Toncheva, Shahlo Turdikulova, Ingrida Uktveryte, Olga Utevska, René Vasquez, Mercedes Villena, Mikhail Voevoda, Cheryl A. Winkler, Levon Yepiskoposyan, Pierre Zalloua, Tatijana Zemunik, Alan Cooper, Cristian Capelli, Mark G. Thomas, Andres Ruiz-Linares, Sarah A. Tishkoff, Lalji Singh, Kumarasamy Thangaraj, Richard Villems, David Comas, Rem Sukernik, Mait Metspalu, Matthias Meyer, Evan E. Eichler, Joachim Burger, Montgomery Slatkin, Svante Pääbo, Janet Kelso, David Reich, and Johannes Krause
2014 Ancient human genomes suggest three ancestral populations for present-day Europeans. *Nature* 513(7518): 409–413.

Levy, Janet E.
2007 Archaeology, communication, and multiple stakeholders: from the other side of the Big Pond. *European Journal of Archaeology* 10(2-3): 167–184.

Leydesdorff, Loet, Björn Hammarfelt, and Almila Salah
2011 The structure of the Arts & Humanities Citation Index: A mapping on the basis of aggregated citations among 1,157 journals. *Journal of the American Society for Information Science and Technology* 62(12): 2414–2426.

Lidén, Kerstin, Gunilla Eriksson, Bengt Nordqvist, Anders Götherström, and Erik Bendixen
2004 "The wet and the wild followed by the dry and the tame" – or did they occur at the same time? Diet in Mesolithic – Neolithic southern Sweden. *Antiquity* 78(299): 23–33.

Lock, Gary, and Brian Leigh Molyneaux (editors).
2006 *Confronting Scale in Archaeology*. Springer US.

Marriner, Nick
2009 Currents and trends in the archaeological sciences. *Journal of Archaeological Science* 36(12): 2811–2815.

Marzano, Mariella, David N. Carss, and Sandra Bell
2006 Working to Make Interdisciplinarity Work: Investing in Communication and Interpersonal Relationships. *Journal of Agricultural Economics* 57(2): 185–197.

McGlade, James
2014 Simulation as Narrative: Contingency, Dialogics, and the Modeling Conundrum. *Journal of Archaeological Method and Theory* 21(2): 288–305.

Milner, N., O.e. Craig, G.n. Bailey, and S.h. Andersen
2006 A response to Richards and Schulting. *Antiquity* 80(308): 456–458.

Milner, N., O. E. Craig, G. N. Bailey, K. Pedersen, and S. H. Andersen
2004 Something fishy in the Neolithic? A re-evaluation of stable isotope analysis of Mesolithic and Neolithic coastal populations. *Antiquity* 78(299): 9–22.

National Institutes of Health
2014 Accessible at: http://commonfund.nih.gov/Interdisciplinary [Accessed 30.4.2015]

Needham, S.
2005 Comments Vi: Rationalizing Materiality. *Archaeometry* 47(1): 192–195.

Niiniluoto, Ilkka
1980 Scientific progress. *Synthese* 45(3): 427–462.

Nissani, M.
1997 Ten cheers for interdisciplinarity: The case for interdisciplinary knowledge and research. *The Social Science Journal* 34(2): 201–216.

Oberheim, Eric, and Paul Hoyningen-Huene
2013 The Incommensurability of Scientific Theories. In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta. Spring 2013.

O'Connell, TC, CJ Kneale, N Tasevska, and GGC Kuhnle
2012 The diet-body offset in human nitrogen isotopic values: A controlled dietary study. *American Journal of Physical Anthropology* 149(3): 426–434.

Parkington, John
1991 Approaches to dietary reconstruction in the western Cape: Are you what you have eaten? *Journal of Archaeological Science* 18(3): 331–342.

Popper, Karl
2002 *The Logic of Scientific Discovery*. 2 edition. Routledge, New Delhi, March 31.

Powers, Simon T., and Laurent Lehmann
2014 An evolutionary model explaining the Neolithic transition from egalitarianism to leadership and despotism. *Proceedings of the Royal Society of London B: Biological Sciences* 281(1791): 20141349.

Preucel, R. W.
2001 Theory in Archaeology. In *International Encyclopedia of the Social & Behavioral Sciences*, edited by Neil J. SmelserPaul B. Baltes, pp. 15647–15652. Pergamon, Oxford.

Psychol, Steve, Richard Standen, and Edward Peck
1997 The challenge of managing community mental health teams. *Health & Social Care in the Community* 5(1): 40–47.

Ramberg, Bjorn, and Kristin Gjesdal
2014 Hermeneutics. Ed. Edward N. Zalta. *The Stanford Encyclopedia of Philosophy*.

Richards, Michael P., Rick J. Schulting, and Robert E. M. Hedges
2003 Archaeology: Sharp shift in diet at onset of Neolithic. *Nature* 425(6956): 366–366.

Richards, M. P.
2002 A brief review of the archaeological evidence for Palaeolithic and Neolithic subsistence. *European Journal of Clinical Nutrition* 56(12): 16 p following 1262.

Richards, M. P., and R. J. Schulting
2006 Touch not the fish: the Mesolithic-Neolithic change of diet and its significance. *Antiquity* 80(308): 444–456.

Robb, John, Timothy R. Pauketat, Clive Gamble, Chris Gosden, Michael Heckenberger, Scott MacEachern, Susan Pollock, Kenneth E. Sassaman, and Ruth M. Van Dyke
2013 *Big Histories, Human Lives: Tackling Problems of Scale in Archaeology*. SAR Press, Santa Fe.

Schiffer, Michael B.
1981 Some Issues in the Philosophy of Archaeology. *American Antiquity* 46(4): 899–908.

Sealy, J. C., and N. J. van der Merwe
1992 On "Approaches to dietary reconstruction in the Western Cape: Are you what you have eaten?"—A reply to Parkington. *Journal of Archaeological Science* 19(4): 459–466.

Shennan, Stephen, Sean S. Downey, Adrian Timpson, Kevan Edinborough, Sue Colledge, Tim Kerig, Katie Manning, and Mark G. Thomas
2013 Regional population collapse followed initial agriculture booms in mid-Holocene Europe. *Nature Communications* 4.

Snow, C. P., and Stefan Collini
1993 The two cultures: a second look (1963). In *The Two Cultures*. Canto. Cambridge University Press.
2012 *The Two Cultures*. Reissue edition. Cambridge University Press, Cambridge, U.K. ; New York.

Solomon, Christopher T., Stephen R. Carpenter, James A. Rusak, and M. Jake Vander Zanden
2008 Long-term variation in isotopic baselines and implications for estimating consumer trophic niches. *Canadian Journal of Fisheries and Aquatic Sciences* 65(10): 2191–2200.

Stein, Julie K.
1993 Scale in archaeology, geosciences, and geoarchaeology. *Geological Society of America Special Papers* 283: 1–10.

Thomas, Julian
2003 Thoughts on the "Repacked" Neolithic Revolution. *Antiquity* 77(295): 67–74.

Thorpe, I. J.
1999 *The Origins of Agriculture in Europe*. 1 edition. Routledge, London, August 6.

Tite, M. S.
1970 The impact of the natural sciences on archaeology. *Contemporary Physics* 11(6): 523–539.

Torrence, Robin, Marcos Martinón-Torres, and Th. Rehren
2015 Forty years and still growing: Journal of Archaeological Science looks to the future. *Journal of Archaeological Science* 56. Scoping the Future of Archaeological Science: Papers in Honour of Richard Klein: 1–8.

Trigger, Bruce G.
1998 Archaeology and Epistemology: Dialoguing across the Darwinian Chasm. *American Journal of Archaeology* 102(1): 1.

Troy, Christopher S., David E. MacHugh, Jillian F. Bailey, David A. Magee, Ronan T. Loftus, Patrick Cunningham, Andrew T. Chamberlain, Bryan C. Sykes, and Daniel G. Bradley
2001 Genetic evidence for Near-Eastern origins of European cattle. *Nature* 410(6832): 1088–1091.

Venclová, Natalie
2007 Communication within archaeology: do we understand each other? *European Journal of Archaeology* 10(2-3): 207–222.

Wagner, Günther A, Christopher E Miller, and Holger Schutkowski (editors).
Natural Science in Archaeology. Springer.

Wear, David N.
1999 Challenges to Interdisciplinary Discourse. *Ecosystems* 2(4): 299–301.

Weber, Max
1949 *On the methodology of the social sciences*. Glencoe, Ill. : Free Press.

Weisberg, Michael, and Ryan Muldoon
2009 Epistemic Landscapes and the Division of Cognitive Labor. *Philosophy of Science* 76(2): 225–252.

Weiss, Ehud, Mordechai E. Kislev, and Anat Hartmann
2006 Autonomous Cultivation Before Domestication. *Science* 312(5780): 1608–1610.

Woodcock, Paul, David P. Edwards, Rob J. Newton, Felicity A. Edwards, Chey Vun Khen, Simon H. Bottrell, and Keith C. Hamer
2012 Assessing trophic position from nitrogen isotope ratios: effective calibration against spatially varying baselines. *Naturwissenschaften* 99(4): 275–283.

Wylie, A.
2001 Archaeology and Philosophy of Science. In *International Encyclopedia of the Social & Behavioral Sciences*, edited by Neil J. SmelserPaul B. Baltes, pp. 614–617. Pergamon, Oxford.