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RESEARCH

# Ontologies of the Future and Interfaces for All: Archaeological Databases for the Twenty-First Century

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**ABSTRACT**

Archaeological database management systems serve the basic and important functions of ordering, archiving, and disseminating archaeological data. The increased availability of computers and data storage over the past two decades has enabled the exponential growth of archaeological databases and data models. Despite their importance and ubiquity, archaeological database systems are rarely the subject of theoretical analysis within the discipline due to their ''black box'' nature and the perceived objectivity of computerized systems. Inspired by H. Martin Wobst's meditations on materiality and disciplinary ethics, in this paper I explore how archaeological database systems structure archaeological interpretation and disciplinary practice. In turn, I offer suggestions for how archaeological database systems can better support pressing anthropological research topics of the 21st century including multivocality, participatory research and ethics, social memory, and social complexity studies.

Résumé: Les systèmes de gestion de base de données archéologiques remplissent des fonctions élémentaires importantes consistant à ordonner, archiver et disséminer les données archéologiques. La présence croissante d'ordinateurs et de solutions de stockage de données au cours des deux dernières décennies a permis un accroissement exponentiel des bases de données archéologiques et des modèles de données. En dépit de leur importance et de leur ubiquité, les systèmes de bases de données archéologiques font rarement l'objet d'analyses théoriques au sein de la discipline en raison de leur caractère de « boîte noire » et de l'objectivité perçue des systèmes informatiques. Les méditations de H. Martin Wobst sur la matérialité et l'éthique de la discipline ont inspiré cet article dans lequel j'explore la façon dont les systèmes de bases de données archéologiques structurent l'interprétation archéologique et les pratiques de la discipline.

Ce faisant, j'offre des suggestions sur la façon dont les systèmes de bases de données archéologiques peuvent appuyer de manière plus efficace la recherche anthropologique courante sur les sujets d'intérêt du 21e siècle dont la multivocalité, la recherche et l'éthique participatives, la mémoire sociale et les études de la complexité sociale.

Resumen: Los sistemas de gestión de bases de datos arqueológicos sirven para las funciones básicas e importantes de ordenar, archivar y difundir los datos arqueológicos. La creciente disponibilidad de ordenadores y almacenamiento de datos a lo largo de las dos últimas décadas ha permitido el crecimiento exponencial de las bases de datos arqueológicos y de modelos de datos. A pesar de su importancia y ubicuidad, los sistemas de bases de datos arqueológicos son raras veces el objeto del análisis teórico dentro de la disciplina debido a su naturaleza de "caja negra" y la objetividad percibida de los sistemas informatizados. Inspirado por las meditaciones de H. Martin Wobst sobre la materialidad y la ética disciplinaria, en el presente documento exploro cómo los sistemas de bases de datos arqueológicos estructuran la interpretación arqueológica y la práctica disciplinaria. A su vez, ofrezco sugerencias sobre cómo los sistemas de bases de datos arqueológicos pueden apoyar mejor los temas acuciantes de la investigación antropológica del siglo XXI, incluidos los estudios sobre multivocalidad, investigación participativa y ética, memoria social y complejidad social.

**KEY WORD**

Databases, Information systems, Ontology, Participatory research

Databases are central to archaeological knowledge production, as they serve to order, archive, and disseminate data gathered through survey, excavation, and analysis. The increased availability of computers and data storage has enabled the exponential growth of archaeological databases and data models. Despite their importance and ubiquity, archaeological database systems are rarely the subject of theoretical analysis within the discipline. Inspired by H. Martin Wobst's critiques of disciplinary methodologies, I offer three futurecasts for archaeological databases. These predictions are meant to be a thought-provoking, not prescriptive, exploration of how archaeological databases may better put into practice certain theoretical developments in the field regarding multivocality, participatory research and ethics, social memory, and social complexity studies. Such applications

will contribute to new modes of representing archaeological data that reflect alternative and synchronously evolving worldviews. As my title suggests, these developments will play out both in terms of organizational frameworks of archaeological knowledge (i.e. the concepts, relations, and vocabulary that comprise the ontologies of archaeological information) and modes of accessing and interacting with archaeological data (i.e. interfaces).

## The Social Lives of Archaeological Databases

A database is any systematized assemblage of data points. Technically, this is different from the database management system, which is the framework used to create and interface with the database. However, for the purpose of this paper, I am collapsing this distinction. When I use "database" I am referring to these dual functions as collection and organizational system, and am implicating their roles as both "products and precedents" (Wobst 1999) of archaeological knowledge. That is, databases are an artifact of archaeological knowledge production and also structure subsequent knowledge production.

As archaeologists, we rely upon our databases to store our field and lab observations for future retrieval—both for interpretive purposes and posterity. Because many archaeological methods are destructive, databases serve as important archives of former states of being. When preparing a report, we refer to our databases, searching for certain data points or patterns and creating summaries of data aggregates such as quantities of artifacts by form, function, and location. We do this regardless of the complexity of our software—from paper-based catalogs to Excel spreadsheets to object-relational database management systems. And often times we do this unthinkingly—as a necessary waypoint between fieldwork and publication—made more efficient and convenient by our computers, which handily calculate sums, normalized counts, and standard deviations with grace and ease.

Yet, archaeological databases have social lives that extend beyond assisting our report write-up. As archive and methodological tool, the archaeological database has power that extends beyond our personal desktops. During the eighteenth and nineteenth centuries, the amassing of archives was an integral component of nation-building and colonization, which objectified collective memory and entrusted an emergent class of experts to steward these materials in service to the national mythos (Hutton 1993:151; Labrador and Chilton 2009:2). Paul Ricoeur characterizes archives as collections of documented, subjective testimonies that have been severed and appropriated from their authors and re-contextualized as a set of authoritative observations of the past (Labrador and Chilton 2009:2; Ricoeur 2006:166). Although the act of

entering information into a database is an interpretive act, the archaeological database is rarely perceived as a subjective or highly contextualized entity itself. And when it has been (e.g. Bruchac 2007), these critiques typically focus on collections amassed during the nineteenth and early twentieth centuries as artifacts of the discipline's colonial knowledge systems.

However, today's archaeological databases go relatively un-examined as historiographic texts that continue to assert expert authority over empirical evidence from the past and to sanitize the sensual nature of material culture by representing it in terms of objective data points. The compulsory appendix of the printed artifact catalog in the back of most site reports—even for progressively-minded community-engaged projects—is testament to the unquestioned "theory-neutral," (Bowker 2000:643) empirical nature of our databases.

Although archaeological theories have moved beyond objective, expert empiricism, and our database technologies have evolved from paper ledgers and punchcards, it is not clear whether our methods of employing databases have changed all that much. We are less likely to think about the mundane, day-to-day aspects of implementing and populating our databases (Bowker and Star 2000:10) than we are to consider semiotics, field sampling strategies, or public outreach. Yet, as Hutton has noted, the social power of an archive extends beyond legitimating expert authority or determining *what* is to be remembered about the past—the naturalization of archives has actually structured *how* memory is formed (Hutton 1993:151; Labrador and Chilton 2009:2).

It follows then that archaeological databases structure how we "do" archaeology as a component of our social scientific toolkit (e.g., see Hine 2006 for an ethnographic study of the impact of databases in biological sciences). Thus, the cataloguing and data-entry process have impacts upon how we see our data and how we predetermine future modes of access and interpretation.

## Classifications and Multiplicities of Meaning

Looking at the future of our field, my first prediction is that archaeological databases will better represent multiple interpretations. Classification remains a central tenet in archaeological databases. Classificatory systems seek to maximize similarity and minimize difference to create order. As the locus of our implemented classificatory systems, the database is a key artifact of what Bowker and Star (2000:276) have referred to as a bootstrapping problem and what Read (2009:199) calls a double bind: that to have a useful organizational system, you must know the complete bounds and features of your data first. You need to know the full distribution of pat-

terns before deciding which artifacts can be lumped together or split apart. In the absence of complete ontological knowledge, systems may suffer from "reverse bootstrapping," whereby the perceived anomalies are downplayed if not ignored completely (Bowker 2000:650). However, archaeological data are forever incomplete, and these emergent data present challenges both to the human practitioner, who is more able and open to recognizing that which has been found before, and to the database, which is more able to handle rules rather than exceptions to rules. These challenges mean that our classificatory systems and their related standards have extreme inertia (Bowker and Star 2000).

Critiques of archaeological typologies often point out that classes or types are mutually exclusive. Artifact catalogs typically support a single form of identification (Figure 1, top), i.e. an artifact is either a brass point or a glass bead—it's not both. Some databases can further refine this using "faceted" classification (Figure 1, middle), separating material from function, allowing for brass beads and glass points without the need to create two new classes. Some databases may even go further by creating databases of classes—such as a ceramic attribute analysis, which elevates the class "ceramic sherd" to a level that can be further described using ordinal values and additional classes (Figure 1, bottom). In such a case, identifying a "ceramic sherd" in an artifact assemblage is the first step in a chain of more detailed descriptive observations relating to the sherd's paste, surface treatment, and decoration (which can be classed according to density, color, motif, etc.). Thus, the

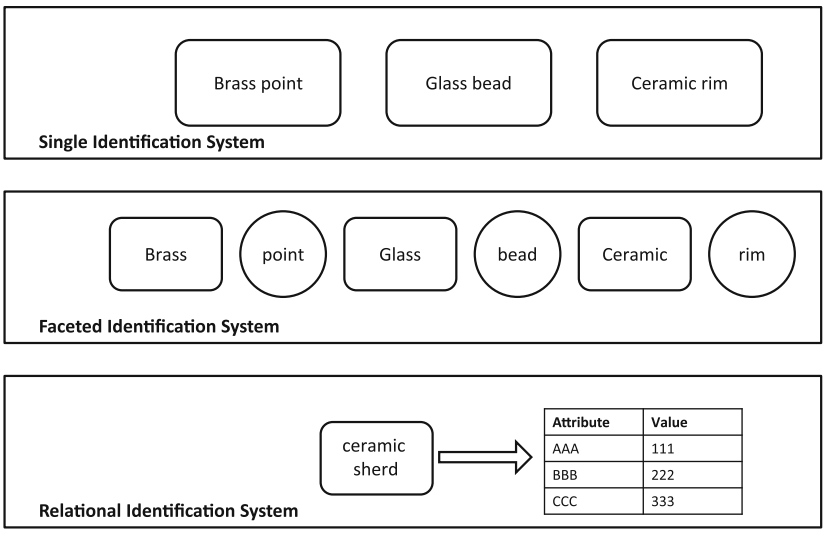


**Figure 1.** Diagram of three basic classificatory schemas

database would contain a series of relationships between the ceramic sherd and its many attributes, reflecting and documenting that certain classes in archaeological databases are shorthand for a series of observations and interpretive steps.

Yet, archaeologists have been talking about multiple interpretations for several decades now, which aren't served well by mutually exclusive classifications. Alternative ontologies, or other ways of conceptualizing and organizing the archaeological knowledge domain, must be better represented in our databases if we are to truly engage with multiplicities of meaning. Kirakosian's (2011) research on the technical and ethical discourse surrounding shell middens shows how archaeologists have traditionally found it difficult to represent artifacts as simultaneously existing within multiple ontological categories (e.g., food waste, tool, burial context) because of our inclination to collapse those categories with the values they signify (i.e. waste = unwanted, tool = practical, burial = sacred). Historically, one class is chosen, such as "food waste" with highly political results; that is, associated burials are deemed unwanted, and thus unimportant, and thus available for plunder, ironically re-valuing the burials for scientific use.

Outside of archaeology, contemporary databases are embracing descriptive tags or multi-select classes that escape mutual exclusivity. This would mean that a shell could carry multiple descriptive tags of different orders, which may have previously been represented as mutually exclusive classes within a given organizational hierarchy: e.g., fauna, food remains, tool, sacred. This may seem heretical as it goes against the unspoken rule in empirical artifact catalogs: thou shalt count thy artifacts *once*. With four separate tags, an item could be counted four times if the archaeologist aggregated in the standard typological way (i.e. counts of artifacts by class). But, we've actually created a new value—revealing difference in the number of tags can inform us of, say, the range of variation and relationships among cultural values. Moreover, it may point to systemic incompatibilities in our technical systems of classification and the originating culture's worldview, inviting us to reevaluate our technical infrastructures and attendant ethical values in our identifications.

As computing has returned to distributed network models (like giant mainframes distributed across the internet—or "in the cloud"), there has been a move toward generating content and metadata standards (i.e. consistent criteria by which data are recorded and described) so that disparate and ontologically incompatible databases may be amassed, reconciled, and mined for patterns. This trend holds the potential to broaden the scale of archaeological databases (beyond the field site) and support collaborative and even interdisciplinary research (at the database level). However, this remains a major challenge for archaeological databases because of the strength and character of our "local data cultures" (Bowker 2000:653) wherein point

typologies for the same region may use differing terms depending upon author, locale, or whim. As more heterogeneous data are amassed, the need for a more homogeneous ontology tends to increase. Metadata standards intentionally set limits—recognizing certain features while excluding others. We should keep in mind that creating such standards is an ethical and often political act, and one that cannot be taken lightly.

## Audience and Participatory Information Models

My second prediction is that our databases will become more accessible to wider audiences and implement participatory models to fully engage with the performative ideals of multivocality and collaborative research. This is already happening among those who work in public interpretation contexts where databases are articulating with emergent knowledge communities and acknowledging a wider frame of "expertise."

For instance, "organic" or collaborative tagging as a form of classification has grown especially popular among user-driven websites where users define and apply their own descriptive labels (i.e. tags) to data objects, resulting in emergent "folksonomies" (Vander Wal 2007) that reveal and produce communities of practice. A popular, contemporary instance of organic tagging can be seen on flickr (http://www.flickr.com), where users describe digital photographs with self- and predefined descriptive tags such as "California," "portrait," "Nikon," "square," "sepia," and "romantic." A single photograph can carry multiple tags, which are not further organized by type; for instance, "California" and "square" are treated as the same type of logical entity, a tag, rather than being slotted into predefined logical attributes such as "geographic location" or "shape." Users can search content by tags, follow emergent paths of related tags (i.e. tags that are often co-listed on a single photograph), and join social groups formed around interests in specific tags. In the academic research community, a similar example of collaborative tagging can be seen at HASTAC (http://www.hastac.org), which stands for Humanities, Arts, Science, and Technology Advanced Collaboratory. In HASTAC, user-generated content, such as blog entries, events, and funding opportunities, is tagged, as are the collaborative working groups that form through engaging with the online system. The folksonomy that emerges on HASTAC both delineates and bridges traditional research silos, enabling scholars to find colleagues within and across their disciplinary boundaries with shared research interests. Such systems acknowledge that data are valuable in terms of contemporary significance and shared inferred meanings (Vander Wal 2007) that have power to signify emergent user collectives. Inviting an audience to tag

is one small, albeit potentially significant, step toward sharing the power of expertise.

User tagging raises the question of audience. Who are our audiences? And who should our audiences be? There are two general types of archival database users: academic researchers and information seekers (Adams 2007). Archaeological databases have been designed for the prototypical academic researcher, who is trained to treat its content as empirical data whose value lies in aggregates. Information seekers use archival databases to search for specific and often highly-personal data points. According to a recent survey of users of the US National Archives and Records Administration (Adams 2007), these users now far outnumber the academic researcher type. Primarily, these new users are involved in family history and genealogical research, a phenomenon that co-author, Elizabeth Chilton, and I have explored in an earlier paper (Labrador and Chilton 2009) in which we urge archaeologists to adapt the structures and interfaces of successful genealogical tools, such as Ancestry.com, to archaeological databases. I am not suggesting archaeologists strive to cater to genealogists, but to learn from the allure of such information-seeking research and their tools.

I believe that highly personalized information seeking has the potential to engage users with broader historical, political, and ethical issues—and that we have an excellent opportunity to make public archaeology personal, and vice versa. Take for instance the *Children of the Lodz Ghetto* collaborative research project hosted by the U.S. Holocaust Museum. This online project invites public participants to comb archives to "tell the stories" of 14,000 schoolchildren whose handwritten Rosh Hashanah "wishes" were documented in an album held by the museum (Simon 2010; U.S. Holocaust Museum 2011). Volunteers conduct online research from their computer using free digital resources provided by the museum. First, the participant chooses a student to research (students can be browsed by name, school, gender, and whether any prior research has been conducted). The website then guides the researcher through five stages of research: (1) verifying the identity of the student; (2) documenting evidence of their life in the ghetto; (3) documenting evidence of their service in labor camps; (4) documenting evidence of whether they were transported to and/or killed at a concentration camp; and (5) documenting evidence of their survival of the Holocaust. The participant submits each stage of their research to a reviewer to be approved and can reach out to other researchers and reviewers with specific questions through an online discussion board. Other participants are free to add more documentation and annotations to each research stage, which is also open to threaded discussion among registered users. Thus, a collaborative research community emerges, and each student's record prompts dialogue, which can range from meta commentary on the research process itself to substantive comments about the content of the documentation. When a participant feels

that all possible research avenues have been exhausted, they are invited to write an interpretative biographical narrative for the selected student.

Although it would be more efficient for museum staff to do this research on their own, the value in engaging users with such research is arguably more powerful than listing the end results for their perusal (Simon 2010). By seeking information about specific children of the Lodz Ghetto, participants learn more deeply about the forced movement and labor and genocide of Jews and other persecuted individuals under the Nazi regime. Participants may gain a new perspective on the scale of such atrocities when combing through the numerous records, and investigating the details of the students' lives may better serve to humanize them as individuals rather than anonymous statistics. Volunteers also learn important lessons about the accuracies and idiosyncrasies of historical archives as they cope with confusing and conflicting data—potentially learning that archives are cultural artifacts with particular historical contexts and not simply records of fact. Finally, there is a form of emotional attachment that can grow between the researcher and her subject (and other fellow researchers) in this instance that can have profound implications for realizing more empathetic models of learning history.

In the cultural heritage sector, the Reciprocal Research Network (RRN), co-developed by the Musqueam Indian Band, the Stó:lō Nation/Tribal Council, the U'mista Cultural Society and the Museum of Anthropology at the University of British Colombia is an inspiring example of collaborative research and intercultural exchange centered around sixteen institutions' collections of cultural objects from First Nations peoples of the Northwest Coast (Carr-Locke and Nicholas 2011; RRN 2012; see also Nicholas et al. 2011 for more examples on the horizon). Placing several museum archives online through a single interface grants easier access to those who cannot travel to the individual institutions' physical locations. Moreover, projects such as the RRN and the Denver Museum of Nature and Science go beyond providing access by opening and extending the interpretive framework to their collections' associated memory keepers and their communities. In these instances, the voices of those cultures represented in the collections can be heard through their input in the interpretation of specific objects, which annotates and enriches the online database as well as informs physical placards at the museum (Carr-Locke and Nicholas 2011). I invite us to imagine and experiment with more such projects whereby the archaeological database becomes a platform for forming participatory learning environments with associated communities and beyond. Those who experiment with such models can contribute their reflections about how our databases can assist with demonstrating the power of our discipline and how better to share that power with others. Additionally, what do archaeologists learn from various communities of users by opening

access to our data stores? And perhaps most importantly, what broader social impacts are made by and felt by those participating in such projects?

## Representing Complexity

My third prediction is that archaeological databases will experiment with new ways of structuring knowledge representations to better model the complexity of social life. The shift from data processing to information processing has been fueled both by advancements in technological computing capabilities (which allow for the amassing and processing of huge, multi-dimensional datasets) as well as broader theoretical developments concerning the modeling of social complexity. Rather than treating database content as straightforward, empirical evidence that is inputted and outputted in pre-determined ways, more researchers are adopting exploratory learning models to recognize novel patterns and implicit knowledge representations embedded within data (Weissman 1994).

Experiments combining community-driven "fluid ontologies" (Srinivasan and Huang 2005) with human-centered user interface design have begun to explore how alternative worldviews can be better mediated and represented to serve specific communities of users such as descendants and memory-keepers. For instance, the technical specification for the "ontologically-flat" multimedia tool of TAMI (Text, Audio, Movies, Images), was developed in response to attempts at representing Aboriginal knowledge structures in digital archives in Australia (Christie 2004; Indigenous Knowledge and Resource Management in Northern Australia 2006). Rather than determining and encoding an Aboriginal data model at the start of the project, TAMI's developers propose completely flattening the data structure so as to remove all prior assumptions about the world and designing a graphical interface whereby indigenous users could intuitively create their own relationships, labels, metadata, queries, and meanings within the system (Christie 2004). TAMI's users, who would include Aboriginal teachers, parents, and elders could create "local memory databases," encoding the larger archive with personally meaningful collections of heritage data whose cultural significance they communicate to younger generations: their students, children, and grandchildren (Christie 2004; Verran 2007). Furthermore, TAMI's developers followed human-centered design principles, meaning that they elicited and prioritized the needs of the user community when specifying the software design. This framework led to the developers prioritizing a database system that was intuitive to users who aren't technically savvy, may have trouble using keyboards, and may lack literacy skills (Indigenous Knowledge and Resource Management in Northern Australia 2006). Such experiments move one step beyond collaborative research and into the realm of participa-

tory knowledge modeling, blurring the lines between information architect and database user (Christie 2004).

The current interests in social complexity, non-linearity, and the mutual-constitution of traditional binaries such as nature/culture, object/subject, and time/space, will lead to developments in our own technical knowledge structures. And I don't confine my predictions to the most abstract post-processualists out there. Experiments in relational statistics (Neville and Jensen 2002; Neville et al. 2004) and temporal networks (Rossi and Neville 2011) are moving beyond the fundamental assumption that statistical data are individually and identically distributed and recognizing instead their structural interrelatedness. These experiments recast statistical bias as an embedded artifact of the structure of the information domain, and thus something to work with rather than around. In other words, these researchers are treating uncertainty, bias, variance, and anomalies as welcome sources of knowledge rather than pesky "errors" to diminish or eliminate from statistical models. Such developments may offer innovative statistical alternatives to archaeologists who wish to explore, identify, and quantify patterns in archaeological data (which are typically relational and temporal).

Destablilizing the empirical nature of archaeological databases will undo the assumptions we hold regarding the relationships between cause and effect in material culture and human behavior. Doing so may help us to better recognize and appreciate absence in databases, in addition to presence, and to better ponder the implications for our datasets when Wobst theorizes artifacts as "material interferences." In other words, analyzing absences and anomalies within datasets may lead us closer to understanding that which was taken for granted within a social milieu rather than equating material presence with cultural presence.

## Conclusion: A Call to Action and Support

As we experiment with our databases, we invite new ways of doing archaeology that better meet the ethical ideals of contemporary archaeological theory. It is time that we join our forward-thinking colleagues in information science, library science, museum studies, and science studies, and to collaborate with those who have taken experimental steps toward implementing new ontologies and data models. We must reflexively approach our own databases and understand their social lives including the genealogical roots of our classifications and data structures and their attendant political and ethical goals. We must acknowledge and respect that our databases are products of our knowledge domain and precedents of our future world.

While computers have allowed us to more efficiently manage ever increasing amounts of data and attendant classificatory schemes, they also offer us incredible opportunities to make the boundaries between expert and audience more porous and to invite users into the immersive world of material culture research. Community collaboration can persist through the database construction stages to better support multiple interpretations, contemporary significance, and cultural variation.

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