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Standards and quantification of coin iconography: possibilities and challenges

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Abstract

The use of digital technologies and big data in the humanities and social sciences provided many opportunities for cultural heritage management and research, enabling data sharing and interdisciplinary collaborations. These developments increased the need for standardized data formats. General and domain-specific standards for describing and classifying cultural data, based on linked data principles, are developed to support increasingly numerous digital collections. However, the existing standards do not fully address the particular challenges concerning the standardized descriptions of images. Here we focus on ancient coins, an official image-bearing medium. We present current approaches to coin iconography, including the application of statistical measures to infer patterns in the use of images for communication. We discuss the importance of consistent, standardized data for quantitative research, and propose a generalized approach, focused on basic concepts and limiting the level of detail for the sake of simplicity, interoperability, and compatibility with statistical methods, as a necessary first step towards creating reliable iconographic standards.

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1 Introduction

In recent years, the scope and volume of research on human history have been expanded by the advancements in information technology, which allowed the creation of large online databases of cultural data, from digital libraries to interactive virtual museum collections, preserving cultural heritage and making it broadly available. A rapidly growing field of digital humanities has been developing computational approaches for data management and analysis. This digital revolution has created new possibilities for research, but it has also opened new questions and challenged traditional methods and practices. The existing systems of knowledge organization in humanities, such as terminologies and typologies, are not always consistent, nor commonly accepted, which complicates the process of digitization and the potential for cross-disciplinary collaboration. Moving resources and research to the digital domain requires rethinking classification systems, and transforming cultural data to be suitable for computational approaches.

In this article, we discuss the importance of data standardization for the advancement of research in the humanities. We first give a brief overview of the current trends in managing digital collections of cultural heritage, especially that of classical antiquity, and discuss the issues concerning the development of standards for describing iconography, focusing on ancient coins. Here we will present different approaches to coin images, including recent examples of using quantitative methods to study their meaning, and attempts at creating standards to describe and classify them. On the example of our recent study investigating the informational value of images on Ancient Greek coins, we discuss the challenges of choosing the appropriate level of detail to keep standards useful, but simple, and illustrate the importance of reliable, standardized data as a prerequisite for a successful implementation of statistical measures.

The Linked Open Data principles of the Semantic Web (Berners-Lee, 2006) provided a framework for data standardization and organization using ontologies, formally defined sets of key terms and concepts marked by unique identifiers, connected with semantic links. Adopting this systematic way of describing, managing, and storing data enabled cross-disciplinary

collaborations and data sharing between the researchers in different disciplines of the humanities (Binding and Tudhope, 2016; Huvila, 2019). The CIDOC Conceptual Reference Model, developed by the International Council of Museums, first offered a general framework to represent cultural heritage (CIDOC, n.d.). This standard was further developed by international collaborative projects such as CLAROS (Kurtz *et al.*, 2009), *Europeana* (Doerr *et al.*, 2010; Europeana, n.d.), and ARIADNE (ARIADNE, n.d.), which support digitization and integration of collections of diverse data types: books, manuscripts, music, art, and archaeological artefacts.

General standards and mediating platforms provide essential technical and logistic support for creating domain-specific standards. Early on, scholars of the Ancient World have recognized the potential of standardized data formats for organizing digital cultural data, and adapted them to fit the needs of their own research (Elliott *et al.*, 2014). These efforts have mostly focused on developing guidelines and tools for editing corpora of literary sources (Perseus Digital Library, n.d.; Smith *et al.*, 2000), epigraphic documents (Elliott *et al.*, 2006; Liuzzo, 2014), and prosopographies (Bodard *et al.*, 2017) of Greco-Roman antiquity. Recently, specialists studying material culture joined this initiative, creating standardized concepts and ontologies for organizing digital collections of coins (Nomisma.org, n.d.; Gruber *et al.*, 2013), weights and measurements (Pondera, n.d.; Doyen, 2018), and pottery (Kerameikos.org, n.d.; Gruber and Smith, 2015). The *Pelagios* project (Pelagios Network, n.d.; Barker *et al.*, 2016) provided a common platform integrating different resources through standardized identifiers for annotating ancient places. However, despite rich online collections of artefacts bearing figurative representations (e.g., Arachne, n.d.; Classical Art Research Centre, n.d.; Bibliothèque nationale de France, n.d.; British Museum, n.d.), there is currently no standardized approach for encoding ancient images. A popular tool for analysing mythological depictions in ancient art, the *Lexicon Iconographicum Mythologiae Classicae*, is available online as a database of records on ancient artefacts and the associated bibliography (LIMC France, n.d.), but its potential as a semantic knowledge organization system has not been fully explored.

coordinated by Maria Caccamo Caltabiano. Their goal is to develop ‘an objective and scientific method for interpreting coin types’ based on a structural analysis of motifs, hoping to understand the visual ‘language’ of coins, considered to be analogous to spoken or written language (Caccamo Caltabiano, 2018, pp. 77–8). An important contribution of this project is an online database of ancient coin iconography (*DIANA*), based on the previously published indices (Caccamo Caltabiano, 2007). At present, the database includes 938 Greek and Roman coins, their motifs organized in a hierarchy of four macro-categories (person, animal/monster, flora, and object) with numerous subcategories (posture, sex, age, clothing, attributes). The metadata give information on the provenance, value and date of each coin, allowing the users to explore the distribution of motifs and their combinations through time and space (Caccamo Caltabiano *et al.*, 2013; Celesti *et al.*, 2017). Still under development, this database is mainly used by the researchers associated with the LIN project for case studies focused on specific motifs and their assumed semantic links, trying to interpret the observed diachronic patterns of use of these images by different ancient mints (Puglisi, 2014; Sapienza, 2017). While undoubtedly useful for information organization, the explanatory power of their semantic approach has been criticized (de Callatay, 2018).

The potential of comprehensive coding of iconographic elements pioneered by the *DIANA* database was further developed through the cooperation between the computer scientists from the Big Data Lab at the Goethe University in Frankfurt and numismatists working on the ongoing *Corpus Nummorum Thracorum (CNT)* project based in Berlin (*Corpus Nummorum Online*, 2014–20). In a recent article, Patricia Klinger and colleagues address the disadvantages of using unstandardized free-text descriptions to represent coin iconography in digital databases, which reduces the querying options to simple keyword searches (Klinger *et al.*, 2018). Using the *CNT* Greek Coins data, they devised a natural language processing-based, semi-automatic process to convert obverse and reverse descriptions to a machine-readable format compatible with the linked data principles. Applying machine-learning algorithms makes this approach less reliant on manual interventions, while still allowing expert supervision. It has a lot of potential to be used

on different numismatic collections and applied to other types of image-bearing objects such as pottery and seals, as an important step towards creating standardized typologies.

Another line of ongoing research is employing automatic image recognition technology, aiming to develop techniques for computer-aided image-based classification of ancient coins. The goal is to help increase the accuracy and speed of primary data processing, expand the research potential of numismatic material, and aid cultural heritage management efforts in combating illegal coin trade (Zaharieva *et al.*, 2007; Jarrett *et al.*, 2012; Cooper and Arandjelović, 2020). Despite the still limited practical success of this method, in their computational approach to coin images, these studies are among the few that consider the information contained in the images in quantitative, mathematical terms, emphasizing the overall structure of images and their regularities, rather than idiosyncrasies.

Numismatists have early recognized the usefulness of statistics for studying the ever-increasing collections of coins and inferring patterns in their sizes, weights, denominations, and iconography, attempting to reconstruct ancient monetary systems and economies (Doyen, 2011; de Callatay, 2011). Images are instrumental for detecting individual types in a coin series (characterized by a unique combination of obverse and reverse dies), and estimating the total number of coins produced by an issuing authority in a given period. Quantitative methods have recently been used to study images themselves, in an attempt to understand the intentions behind the choice of certain motifs and their meaning (Faucher, 2018; Iossif, 2018). Instead of discussing the characteristics of a small number of well-known examples, quantitative approaches provide an opportunity to study the images in the context of all known examples, thus avoiding giving undue importance to potentially exceptional objects (Iossif, 2011; de Callatay, 2018). However, these studies are still limited by the affordances of the database queries, and the lack of reliable coin typologies.

In our recent study, we took a different approach to images on coins produced in the ancient Mediterranean states until the end of the Hellenistic period. We quantified the amount of information concerning the issuing authorities and the economic

trends look similar, the conditional entropy values display subtle differences between the original encoding and the two extreme variants (see Figure 1).

With these differences in mind, we can draw some insights on the influence of two coding alternatives on the frequency distributions of unique motifs, designs, and coin types, and their subsequent effect on the outcome of information theoretic measures. This influence is especially noticeable when considering the difference between the general and specific coding of

portraits of historical and mythological persons. In line with the guidelines presented in Table 1, persons are coded using generic terms ('king', 'queen', 'nymph' etc.) in the general coding variant. In the specific coding, the persons that the experts identified based on the coin legends (inscriptions) or inferred from the context (the time and place of the coin's issue) were labelled by name. When the source databases omitted the person's name, as in the example of the Syracusan nymph Arethusa cited above, we

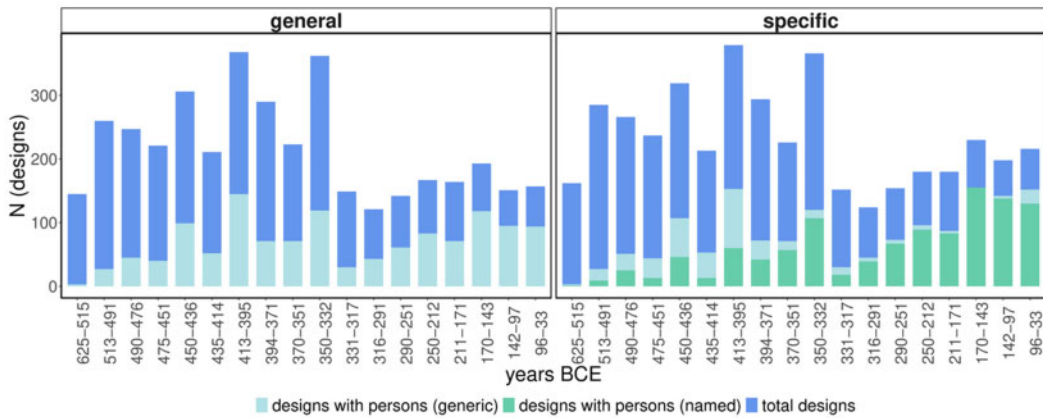


Fig. 2 Frequency distribution of unique design types (blue) in the 'general' and 'specific' datasets. The designs featuring generic persons ('king', 'nymph' etc.) are marked in light blue. The designs featuring named persons (e.g., 'Ptolemy I', 'nymphArethusa') are marked in green

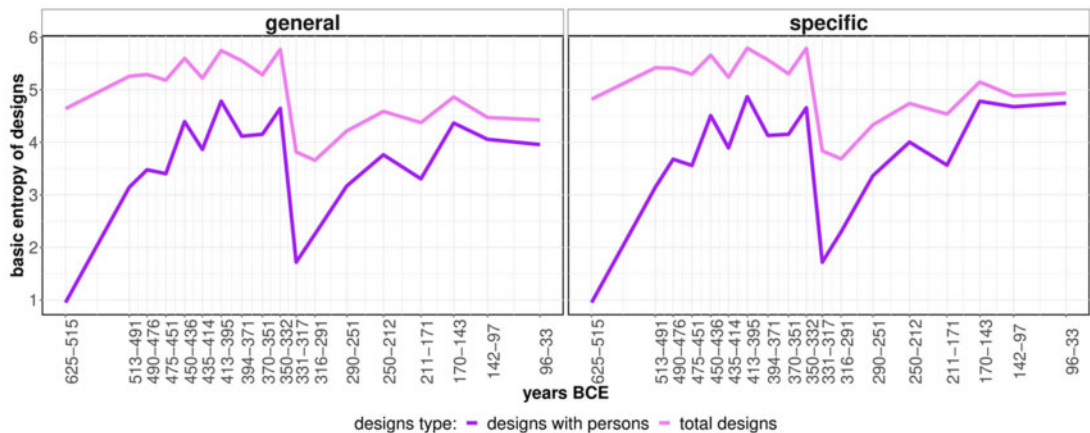


Fig. 3 Diachronic change of basic entropy of designs, measured for 'general' and 'specific' versions of the dataset through eighteen time intervals, separately for designs featuring persons (purple line), and all other designs in a period (pink line)

assigned the names based on the analogous coin types, verifying the suspicious cases in the referent literature (Head, 1911; Kraay, 1976). We strived to be systematic and consistent throughout the coding process, focusing primarily on resolving inconsistencies, and refrained from taking sides in complex numismatic debates on portrait attribution, which were beyond the topic of our study and our level of expertise.

Figure 2 presents the number of unique design types over eighteen time intervals, highlighting the proportion of designs featuring persons. In the ‘specific’ dataset, most persons depicted on coins are identifiable by name, especially in the later periods. Treating them as individual motif types, separate from the generic, unnamed persons, adds to the diversity of motifs composing the designs. This contributes to the increase of the basic entropy of designs (see Figure 3), making them less predictable. Additional design types in the specific coding affect the mapping between designs and authorities or denominations (frequencies of unique denominations and authorities being constant for each of the coding alternatives), inflating the estimates on the amount of information in coin designs. This is why the ‘specific’ designs are overall more informative (indicated by lower conditional entropy values in the final periods) than the ‘general’ ones, especially about the issuing authorities (see Figure 1).

In the Hellenistic period, following the death of Alexander the Great, portraits of rulers appeared on coinage, replacing images of gods and heroes (Carradice, 1978). The portraits of mythological persons, despite their generic character, are identifiable by their attributes, e.g., a lion-skin for Herakles or a helmet for Athena. Hellenistic royal portraits, unlike the generic depictions of the Persian Great King, do display a considerable level of individuality (Carradice and Price, 1988; p. 123 ff.). However, some portraits also tend to be stylistically similar and emphasize the resemblance between the members of the same dynasty, meant to signal continuity and legitimacy of the rulers as heirs of Alexander (Thonemann, 2016, 145 ff.). The attribution of a portrait to a particular historical ruler is thus largely reliant on context: ruler portraits usually appear on their respective coins, often accompanied by inscriptions denoting them as the issuing authority. The existence of inscriptions on coins would assume a certain degree of literacy in their users, and add to the

information encoded in the coin. However, before the middle of the 5th century BCE, the inscriptions were rare and mostly limited to place names (‘ethnics’), followed by the names of rulers and magistrates in the later periods (Kraay, 1976, pp. 2–7; Carradice and Price, 1988, pp. 57–60). In contrast, gods and mythological beings were rarely explicitly named. Nevertheless, as most coins were produced and used locally, it is likely that the contemporary users could recognize the persons depicted on coins, even if recognizable attributes or labels were missing (Weir, 2010).

The ambiguity of designs featuring persons, however, often presents a problem for modern numismatists striving to describe and classify them.² It is, therefore, important to consider the way we code the coin designs, choosing the appropriate level of granularity depending on the hypothesis we are planning to test. In the case of our recent study, since our hypothesis was concerned with the information encoded in the coin’s graphic designs, a generalized coding approach seems to be more appropriate to capture the information directly present in the images, and to avoid introducing artificial complexity derived from the inscriptions and general historical context.

5 Conclusion

The last decade has witnessed a growing number of digital resources, advancements in computer-assisted approaches, and the development of standards for annotating cultural data. This opened new possibilities for management and presentation of cultural heritage. Standardized databases present a way to organize the data, making it more reliable and available for research, suitable for testing different questions using a variety of approaches. However, many challenges remain, especially concerning the digitization of collections of material culture, where finding a generally applicable standard to describe graphic representations seems to be particularly difficult.

In this article, we focused on coins, objects marked with graphic designs, produced in large quantities and disseminated mostly by political authorities, serving primarily as media of exchange. Their official character, together with a substantial number of examples preserved since antiquity, makes them particularly suitable for standardization. In the field of ancient

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Notes

- 1 Accessible online at: <http://numismatics.org/collection/> followed by the catalogue number (e.g., <http://numismatics.org/collection/1997.9.20>).
- 2 For recent examples of studies discussing iconographic representations on the coins issued by Roman emperors through the analysis of relative frequencies of particular coin types, cf. [Noreña, 2001, 2011](#); [Rowan, 2012](#); [Manders, 2012](#).