Are domain-specific theoretical approaches valuable for the application of new computational methods?

The case study of Erwin Panofsky's artworks interpretations and the semantic web

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Abstract: Recently, researchers have shown an increasing interest in the analysis of art-related topics using computational methods. Scholars claim that theoretical perspectives integrated into computational methods may be beneficial when applied to a wider number of artworks, e.g. to ensure consistency and soundness of results. In this article, we examine whether an ontological representation of Erwin Panofsky's approach to artwork interpretations can be validated via quantitative analysis. To this end, we created a Linked Open dataset containing interpretations about ca. 400 artworks, mostly from Middle Ages and Renaissance Western art, modelled according to a new ontology based on the art historian's theory. The research aims at verifying whether 1) data structured according to Panofsky's theory allow answering relevant research questions, and 2) whether characteristics emerging from the data analysis are consistent with his theory. Results show that the creation of an ontology and semantic web data following Panofsky's theory are fit for a computational approach to the study of iconography and iconology and for quantitatively characterising the art historian's approach.

Keywords: iconology, iconography, semantic web, linked open data, Erwin Panofsky

1. Introduction[1]

Recently, researchers have shown an increasing interest in the analysis of art-related topics with computational methods. As some studies highlight, approaches that integrate traditional, established, theoretical perspectives in computational methods may show benefits when applied to a wide number of artworks.[2] However, the efficacy of a traditional theory when applied to a new computational context is not predictable. Assessing to which extent, and to what degree of reliability, well-known theoretical

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[1] S. Baroncini is responsible for Sections 2, 3, 4, 5. All the authors are responsible for Sections 1 and 7.

[2] Harald Klinke, The Digital Transformation of Art History, in: The Routledge Companion to Digital Humanities and Art History, 2020.

approaches to interpreting artworks can be integrated in a computational context is compelling to foster the development of Digital Art History.

In this paper, we address the possibilities offered by the expression of an art historian's method in an ontological fashion. In particular, we investigate a case study on Erwin Panofsky's approach and interpretations represented with Semantic Web technologies, and we estimate to what extent results can be valuable to pursue computer-aided tasks.

Panofsky was chosen as he provides a renowned, consistent, and reproducible theorisation of the Iconographical and Iconological interpretation act.[3] Whereas iconography concerns the description of subjects, their attributes and meanings (e.g. a child with bows, arrows and wings depicted in an artwork is recognized as Cupid), iconology relates the artwork with the socio-cultural context, reframing it as a document of contemporary phenomena – according to the iconological approach firstly introduced by Aby Warburg.[4] In particular, Panofsky formalised the iconographical and iconological attribution in a three-level framework of recognitions: The pre-iconographical description (level 1) is the level at which simple objects, such as people, objects and emotions, are identified; the iconographical description (level 2) is where subjects are associated with iconographies, i.e. characters, themes, stories and allegories, with the aid of the knowledge of representational conventions of artistic subjects; finally, the iconological description (or iconographical synthesis, level 3) concerns the socio-cultural interpretation of an artwork content, closer to Warburg's iconological approach.[5]

The main purpose of this study is to verify whether data structured according to Panofsky's theory (1) allow us to answer iconographical-iconological research questions and (2) if an ontological model based on his theory is consequently valuable for the domain. Moreover, we (3) investigate whether features that characterise Panofsky's approach can be assessed and confirmed via quantitative methods, and if results of the data analysis consistently relate to the definition he makes of his own theory (e.g. if he makes intense use of textual sources as his method seems to suggest).

In summary, we are interested in investigating the following research questions:

RQ1) Do data structured according to Panofsky's theory allow us to answer domain research questions?
RQ2) Can we characterise Panofsky's approach via data analysis?
　RQ2.1) Does data analysis help us in confirming or refusing statements made about his theory?
　RQ2.2) Does he consistently use the three levels of interpretation in his own studies?
　RQ2.3) Can data modelled according to his theory fully represent the complexity characterising an iconological interpretation?

The article is structured as follows. Section 2 provides an overview of the state of the art of computational techniques applied to the Art History field, with a focus on traditional theories embedded in computer science methods. In the same section, an overview of iconographical and iconological themes addressed with Semantic Web technologies is provided. Section 3 includes a description of materials used for the analysis, and in section 4 we describe our approach to the research. In section 5 we present results of the data analysis, which are discussed in section 6. Conclusions, limitations and future works are discussed in section 7.

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[3] Lena Eva Liepe, The Locus of Meaning in Medieval Art: Iconography, Iconology, and Interpreting the Visual Imagery of the Middle Ages, Kalamazoo 2019.

[4] Marion G. Müller, Iconography and Iconology as a Visual Method and Approach, in: Eric Margolis / Luc Pauwels, The SAGE Handbook of Visual Research Methods, London 2011, pp. 283–297.

[5] Panofsky, Erwin, Studies in iconology: humanistic themes in the art of the Renaissance, New York 1962.

2. State of the Art

Scholars adopt a wide range of approaches to analyse images (Computer Vision), texts (Natural Language Processing), and the representation of art historical knowledge as Linked Open Data. Such methods allow us to explore a greater amount of artworks with new methods, such as distant viewing[6], visual pattern detection[7], and quantitative analysis.[8]

Some studies integrate traditional theoretical perspectives in computational methods. Leonardo Laurence Impett[9] translated Warburg's analysis of a 'Pathosformel', visual formula of *pathos* expression, in a computer vision algorithm capable of detecting postures and gestures variations in artworks. By retrieving artwork similarity based on these formulas, it was possible to extend the analysis of the migration of *Pathosformeln* to a wider scale, creating an 'algorithmic Pathosformel'.[10] Another attempt to integrate an established methodology in a computer vision system is made by the Morelli Machine algorithm[11], which reproduces Morelli's method of style attribution, based on the observation of the style of secondary features of the depicted subjects, such as ears and hands. Nevertheless, the application encountered some limits, due to the challenges of tuning the analysis towards the desired focal points.

The interest in the representation and analysis of iconographical and iconological topics is witnessed also by the growing number of standard vocabularies, such as the Getty Vocabularies[12] (i.e. Iconography Authority and Art and Architecture Thesaurus), Iconclass[13], and a few ontologies. The Warburg Institute proposed a model to describe iconographies and their attributes.[14] Similarly, the Visual Representation Ontology (VIR)[15] focuses on the description of visual representations and the recognitions made by scholars, describing the provenance of assertions, and relating different types of iconographical subjects. Ontologies for describing the narrative subject, such as stories, have also been proposed.[16] However, little data about iconography and iconology-related information can be currently found in online available Knowledge Bases (KB).[17]

In summary, experiments in automatic recognition using machine learning or any form of quantitative methods, often require the support of curated metadata to achieve satisfying results, as well as the setting of some rules based on theoretical, traditionally approved, distinction between iconographic elements to be recognised. To this extent, theoretical frameworks for recognising composition elements and

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[6] Lev Manovich, Data Science and Digital Art History, in: International Journal for Digital Art History (2015) 1; Taylor Arnold / Lauren Tilton, Distant viewing: analyzing large visual corpora, in: Digital Scholarship in the Humanities 34 (2019) Supplement_1, pp. i3–i16; Harald Klinke, The Digital Transformation of Art History.

[7] Hans Brandhorst, Meaningful patterns. Can a mix of pattern matching and computer-assisted classification produce a paradigm shift in iconography?, in: Bibliothek und Wissenschaft 55 (2022): Faszination (Buch-)Handschriften im Jahr 2022, 2022, pp. 287–306; Leonardo Laurence Impett, Painting by Numbers: Computational Methods and the History of Art, EPFL, Lausanne 2020; Nikolai Ufer et al., Large-scale interactive retrieval in art collections using multi-style feature aggregation, in: PLOS ONE 16 (2021) 11.

[8] Diana Seave Greenwald, Painting by Numbers, Princeton 2021.

[9] Leonardo Laurence Impett, Painting by Numbers; Leonardo Laurence Impett, Analyzing Gesture in Digital Art History, in: The Routledge Companion to Digital Humanities and Art History, 2020, pp. 386–407.

[10] Ibid., p. 388.

[11] Alison Langmead et al., Leonardo, Morelli, and the Computational Mirror, in: Digital Humanities Quarterly 015 (2021) 1.

[12] https://www.getty.edu/research/tools/vocabularies/.

[13] https://iconclass.org/.

[14] Richard Gartner, Towards an ontology-based iconography, in: Digital Scholarship in the Humanities 35 (2020) 1, pp. 43–53.

[15] Nicola Carboni / Livio de Luca, An Ontological Approach to the Description of Visual and Iconographical Representations, in: Heritage 2 (2019) 2, pp. 1191–1210.

[16] Rossana Damiano / Antonio Lieto, Ontological Representations of Narratives: a Case Study on Stories and Actions, in: Mark A. Finlayson u.a. (eds.), 2013 Workshop on Computational Models of Narrative, Dagstahl 2013, pp. 79–93.

[17] Sofia Baroncini et al., Is dc:subject enough? A landscape on iconography and iconology statements of knowledge graphs in the semantic web, in: Journal of Documentation 79 (2023) 7, pp. 115–136.

symbols are compelling in automatic tasks. Nonetheless, to the best of our knowledge, no prior attempts to formalise iconological assumptions has been performed, which could be valuable to support more sophisticated Computer Vision experiments in the future.

3. Materials

The analysis was conducted over a Linked Open dataset containing interpretations mainly made by Erwin Panofsky about ca. 400 artworks. Artworks mostly include works from the Middle Ages and Renaissance Western art. Figure 1 shows a quantitative overview of the items described in the dataset, according to the ontology.

Data are described according to the ICON ontology[18], which allows the expression of iconographical and iconological interpretations in the Panofskian three-layered model. In ICON, the term *recognition* refers to the identification of a single subject, whereas the term *interpretation* refers to the overall understanding process, composed of all the single recognitions made. Modelling decisions are motivated by the results of a preliminary typological study of iconological interpretations[19] and by the identification of research questions relevant to the domain. In the ontology, the interpretation act is composed of subject recognitions occurring at the different levels of description, as stated by Panofsky. Each recognition identifies only one subject (e.g. a "putto") and some predicates help to record details about it, namely: the responsible person, any citation of supporting evidence, including other recognitions. At the first level of description, Pre-Iconographical Recognition, we can recognise natural elements, actions, and emotions, or a grouping of them. Subjects can be further characterised (e.g. by quantity, colours, and arrangement in space, such as perspective). Iconographical Recognition can then relate such identified subjects to second-level ones, namely: characters, events, places, objects with a specific identity (e.g. the Bible), personifications and symbols. These subjects can be grouped into stories and allegories. Finally, Iconological Reocognitions identify concepts and cultural phenomena.
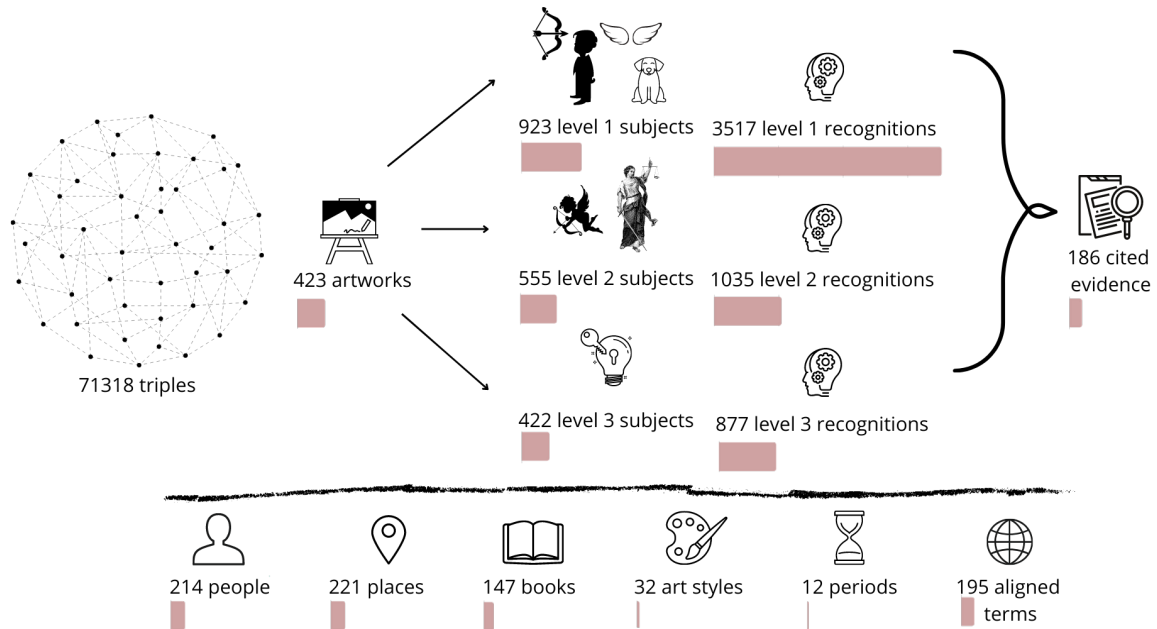

Fig. 1. Quantitative overview of the Iconology Dataset

[18] Bruno Sartini et al., ICON: an Ontology for Comprehensive Artistic Interpretations, in: Journal on Computing and Cultural Heritage (2023).
[19] Sofia Baroncini / Marilena Daquino / Francesca Tomasi, Modelling Art Interpretation and Meaning. A Data Model for Describing Iconology and Iconography, in: AIDAinformazioni 1–2 (2021), pp. 39–62.

4. Approach

This study uses quantitative analysis to gain insights on Panofsky's method and research activity and to validate the consistency of his method when applied to real-world attributions made by himself. The analysis was conducted over the above described RDF dataset of iconological interpretations manually extracted from a selection of his books[20] and modelled according to ICON.

4.1. Iconographical and iconological research questions

The aim of RQ1 is to verify if and how many core research questions relevant to iconological studies can be answered in a quantitative way, or, anyway, if a quantitative approach offers any valuable insights on the topic of interest. Such questions were extracted from a selection of studies and rephrased into sub-questions later expressed as SPARQL queries. Questions are thematically grouped according to their focus, namely: cultural phenomena, iconographies and attributes, symbols, evidence, and citations. Table 1 gives an overview of the questions, the source from which they were extracted, and the sub-questions to be expressed in SPARQL.

Theme	RQ Question from literature	Source	sub-questions
Cultural Phenomena	Which cultural phenomena are witnessed by artworks?	Panofsky[21], Warburg[22]	Q1. How many artworks have a cultural phenomenon associated?
	Which sources and visual aspects motivate their presence?	Panofsky[23], Warburg[24]	Q2. What is the frequency of level 1 and 2 subjects occurring with each cultural phenomenon?
			Q3. What is the frequency with which a cultural phenomenon recognition is supported by a piece of evidence? Of which type is it? (texts, artworks, etc.)
			Q4. Is there any co-occurrence between cultural phenomena and other types of subjects?
		Cardini[25]	Q5. What recognitions support the recognition of a cultural phenomenon?
	How does the representational evolution of subjects witness the emergence of cultural changes?	Panofsky, Saxl[26]	Q6. What are the artworks having both a cultural phenomenon in common and a different style associated?
Symbols	How do symbols evolve?	Wittkower[27]; Panofsky[28]	Q7. Which and how many symbols express the same concept?
			Q8. What different symbolical meanings can the same symbol have?
			Q9. How do symbols evolve over time and in different contexts?

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[20] Erwin Panofsky / Fritz Saxl, Classical Mythology in Mediaeval Art, in: Metropolitan Museum Studies 4 (1933) 2, pp. 228–280; Erwin Panofsky, Meaning in the visual arts, New York 1955; Erwin Panofsky, Studies in iconology: humanistic themes in the art of the Renaissance, New York 1962; Erwin Panofsky, Renaissance and Renascences in Western art, New York 1972.

[21] Erwin Panofsky, Studies in iconology.

[22] Aby Warburg, The renewal of pagan antiquity: contributions to the cultural history of the European Renaissance, Los Angeles 1999.

[23] Erwin Panofsky, Studies in iconology.

[24] Aby Warburg, The renewal of pagan antiquity.

[25] Franco Cardini, The Chapel of the Magi in Palazzo Medici, Florence 2001.

[26] Erwin Panofsky / Fritz Saxl, Classical Mythology in Mediaeval Art.

[27] Rudolf Wittkower, Allegory and the migration of symbols, London 1987 (The Collected essays of Rudolf Wittkower).

[28] Erwin Panofsky, Titian's Allegory of Prudence: a postscript, in Meaning in the visual arts.

	Is the symbolic meaning motivated by a specific source?	Christiansen[29]	Q10. What are all the symbols motivated by a specific source? Do they vary from the corresponding subjects not citing a piece of evidence?
	Is the deeper conceptual meaning motivated by sources?	Warburg[30], Gombrich[31]	Q11. Do deeper meanings cite as support textual sources?
Iconographies	How do iconographies, their meaning and attributes evolve over time?	Panofsky[32], van Straten[33]	Q12. Which are the representational variations of iconography? I.e. what are the sets of level 1 subjects composing the recognized level 2 subject in artworks?
			Q13. What are the attributes having a symbolic meaning?
			Q14. How does the representation of iconography evolve over time? Of which level 1 subjects is it composed?
	What are the attributes allowing us to recognize a subject?	Van Straten[34]	Q15. Which attributes allow us to identify representations? What is their frequency?
			Q16. Among the attributes marked as recognising, which are the most common and rare?
	How does the representation of iconography vary?	Panofsky[35]	Q17. Which are the most common level 1 subjects not marked as recognising?
Evidence	What were the known textual sources to which the artwork refers, and what does this knowledge tell us about the thinking of the time?	Warburg[36]	Q18. What were the known textual sources to which the artwork refers? Is the artwork involved in a cultural phenomenon?
Visual citation	How do visual shapes migrate and re-appear across cultures?	Wittkower[37], Warburg[38]	Q19. What artworks cite the visual pattern of others?
	Is a visual citation the evidence that documents a cultural phenomenon?	Warburg[39]	Q20. In which cases artworks involved in a visual citation have a cultural phenomenon associated?

Table 1. Overview of research questions extracted from the literature, their specification in sub-questions performed in SPARQL queries.

To verify if such questions can be answered we calculate the percentage of answered sub-questions for each thematic group and we characterise answers as addressed, partially addressed (e.g. when limited data are available but the question could be answered via SPARQL queries), and not addressed. Thus, we aim to (1) assess the validity of the ontological model developed to represent Panofsky's theory and the dataset created for demonstration purposes, and (2) estimate to what extent quantitative analysis can be of help when answering traditional art history enquiries.

[29] Keith Christiansen, Lorenzo Lotto and the Tradition of Epithalamic Paintings, in: Apollo 124 (1986).

[30] Aby Warburg, The renewal of pagan antiquity, pp. 4-58.

[31] Ernst H. Gombrich, Botticelli's Mythologies: A Study in the Neoplatonic Symbolism of His Circle, in: Journal of the Warburg and Courtauld Institutes 8 (1945), Warburg Institute, pp. 7–60.

[32] Erwin Panofsky, Meaning in the visual arts.

[33] Roelof Van Straten, An Introduction to Iconography: Symbols, Allusions and Meaning in the Visual Arts, 2. Ed. London 2012 (1. Ed. 1994).

[34] Roelof Van Straten, An Introduction to Iconography.

[35] Erwin Panofsky, Blind Cupid, in: Studies in iconology, S. 95-128.

[36] Aby Warburg, Italian Art and International Astrology in the Palazzo Schifanoia, in: The renewal of pagan antiquity.

[37] Rudolf Wittkower, Allegory and the migration of symbols.

[38] Aby Warburg et al., Aby Warburg: Bilderatlas Mnemosyne : the original, Berlin 2020.

[39] Aby Warburg, The renewal of pagan antiquity.

4.2. Quantitative analysis of Panofsky's approach

To estimate whether Panofsky consistently used his own method when making artwork attributions, we consider the following aspects: (1) whether he consistently reuses texts as primary sources of his interpretations, (2) whether he always uses a three-layer approach when motivating an iconological attribution, and (3) how sophisticated is the network of recognitions, cultural phenomena, and artworks considered in the analysis.

4.2.1. The role of texts

Although it is a central reference for the formalisation of the discipline itself, criticism was raised against Panofsky's theory, with several scholars claiming that he turned Warburg's iconological approach "into a study of the transformation of artistic motifs through their interaction with texts"[40]. Imdahl proposes to add an iconic level to the model, since, according to him, Panofsky's approach focuses on textual sources without giving the right relevance to the iconic language of artworks. Nevertheless, the centrality of documentary sources for conducting an iconographical and iconological analysis is underlined by Taylor.[41] In order to assess to which extent Panofsky motivates his interpretations with pieces of evidence and, in detail, textual sources, we analyse the number of interpretations based on a source, if text sources are more frequent in the recognition of a certain level, and of which type these are.

4.2.2. The three levels of interpretation coverage

RQ2.2 aims at representing the extent to which Panofsky adopts his own theory while interpreting artworks. Since the artworks in the dataset are described according to the three levels whenever the historian addressed them in the original text source, the approach to answer this question is to count how many artworks effectively have all the three levels described, and, if not, to retrieve the levels they are described with.

4.2.3. The complexity of an iconological interpretation

RQ2.3 examines how much the adopted interpretation theory is feasible to represent the complexity of an iconological interpretation. In fact, while explaining his own understanding, the art historian tends to cite artworks, subjects, and phenomena, with the risk of losing the interpretation unity when translated into data. One strategy which was adopted to maintain this unity is to use CiTO[42] ontology and the network of citation relations (*cito:citesAsEvidence*, *cito:givesSupportTo*) to record the link between recognitions and artworks, especially when annotating third-level recognitions. In addition, cultural phenomena are often complex, and an artwork can be witness at the same time of multiple phenomena, e.g. a contemporary phenomenon (e.g. the *interpretatio christiana* of classical deities as the symbol of vices during the Middle Ages) and a more general one (the principle of disjunction, according to which every time a classical theme occurs, it is invested with moral meaning). Consequently, the coexistence of phenomena characterising artworks can give us a hint on the relations between phenomena themselves, and in the art historian's process of interpretation.

Therefore, the analysis focuses on the network of recognitions, artworks, and phenomena, and on filtering of recognitions and artworks related by the CiTO relations. The network is created by including 1) all the phenomena in the selected network, 2) more artworks having a link to the same phenomena, and 3) other phenomena that these artworks are related to. In this way, the resulting network represents the maximum number of relations that can be retrieved from data. The analysis verifies whether the network presents a high number of connections, showing therefore the complexity of iconological

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[40] Lena Eva Liepe, The Locus of Meaning in Medieval Art, p. 17.
[41] Paul Taylor, Iconography without texts: [colloquium, Warburg Institute, 3-4 June 2005], London 2008 (Warburg Institute colloquia).
[42] https://sparontologies.github.io/cito/current/cito.html.

interpretations. Then we qualitatively assess if clusters follow the same narrative presented by the author in the selected books, or if the network shows alternative, unforeseen, paths between topics.

5. Analysis[43]

5.1. Overview

We first provide an overview of the dataset to better frame the results described in the following sections. The majority of artworks having an explicit date (68,5%) is dated between 1100 and 1700 (fig. 2.a.). Therefore, the dataset mainly represents Western Medieval, Renaissance and Late Renaissance art. In addition, the main themes covered belong to the classical repertoire; half of the artworks are linked to a phenomenon related to classical antiquity ("Reception of classical antiquity", fig. 2.c) and the most frequent second-level subjects are mythological characters (fig. 2.d). Although the dataset is focused on Panofsky's interpretations, other authors' interpretations are included (fig. 2.b). The second represented author, Fritz Saxl, is a co-author of one of the source texts. Other authors are included because of the results of a preliminary case study[44], whose results were used as a reference for the modelling choices. Interpretations by other authors are sometimes cited by Panofsky himself; some information was integrated by the paper author on the basis of the direct observation of the artworks' described by Panofsky in the selected literature.
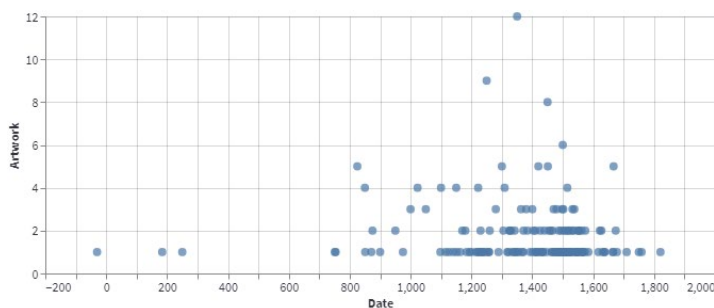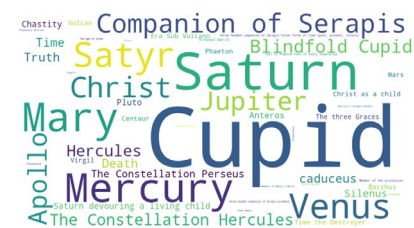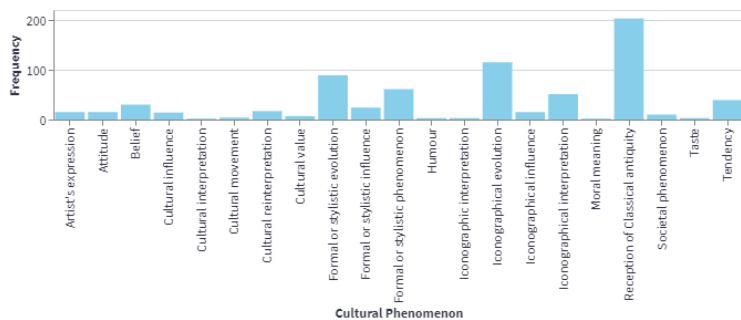
2a)
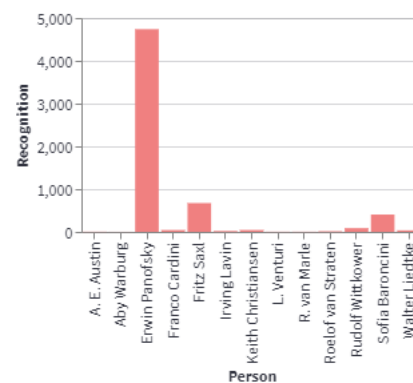
2b)

2c)

2d)

Fig. 2. a) Frequency of artworks per date; b) the number of recognitions per person responsible; c) most frequent second level-subjects; c) frequency of cultural phenomena types.

5.2. Domain-specific research questions

In our analysis[45], all the sub-questions were translated into SPARQL queries and performed against our dataset. As shown in Table 2, around 75% of queries could be answered, while a quarter of them (25%) was not fully answered due to missing or limited data that hamper a reliable analysis of the phenomenon. For example, symbols rarely appear multiple times (i.e. the dataset includes very diverse subjects), hindering the observation of their evolution over time.

Theme	Fully addressed		Partially addressed	
	Questions	*Percentage*	*Questions*	*Percentage*
Cultural phenomena	Q1, Q2, Q3	66,67%	Q4, Q6	33,33%
Symbols	Q7, Q8	60%	Q9, Q10, Q11	40%
Iconographies	Q12, Q13, Q15, Q16, Q17	83,33%	Q14	16,67%
Evidence	Q18	100%		0
Visual citations	Q19, Q20	100%		0
Total		75%		25%

Table 2. Percentage of addressed and partially addressed sub-questions expressing the RQs of the domain

5.3. The art historian's Method and Practice

5.3.1. The usage of textual sources

RQ2.2.1 concerns the role of textual sources in the interpretation process. In contrast to what was expected, only 27% of the overall interpretations are supported by evidence (Fig. 3.a). Considering recognitions that are part of interpretations (Fig. 3.b), those recognitions citing more often a piece of evidence are the iconological recognitions (third level). Although the evidence consisting of a textual source (Information Object, Fig. 3.c) is potentially relevant at all levels, it is less cited when proposing

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an iconological recognition. On the contrary, the majority of recognitions cite other artworks as supportive proof. Figure 3.d shows that artworks are the most frequent type of evidence (72 items), compared to texts (41 items).
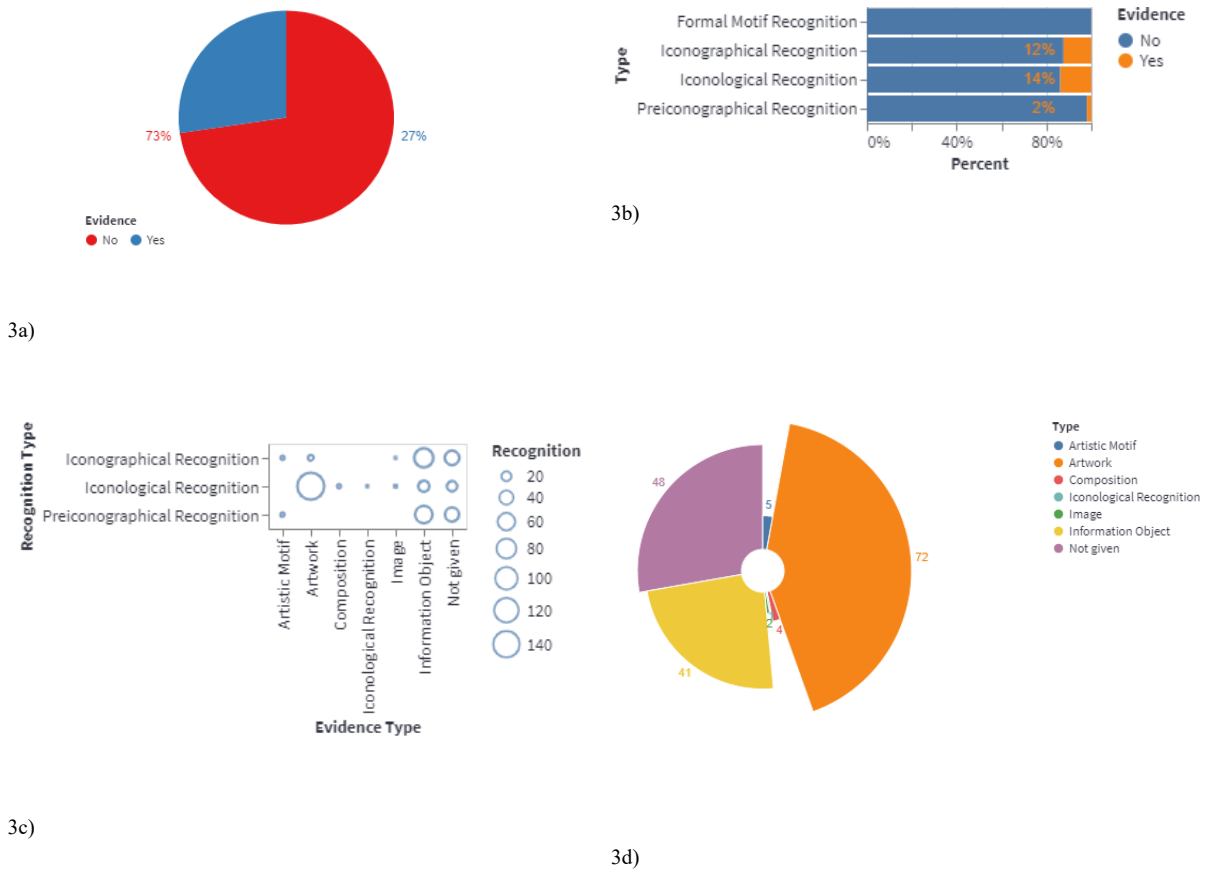

Fig. 3: a) Percentage of interpretations citing evidence; b) percentages of recognitions citing evidence; c) correlation between recognition and evidence type; d) frequency of piece of evidence divided per type.

5.3.2. Levels of description

RQ 2.2.1 concerns to which extent Panofsky adopts, in his interpretations, his own three-level interpretation theory. Since he emerges as the prominent figure accountable for acknowledgments within the dataset, a comprehensive examination was performed on the entire dataset. Surprisingly, only nearly half of the artworks (53%) have at least one recognition at all three levels of interpretation (Fig. 4.a). Among the subset of artworks having only one level described, the majority have only the third level (68%, fig. 4.b), whereas, among the ones described at two levels, the prevailing number of artworks comprises those annotated at levels 1 and 2 (13%).
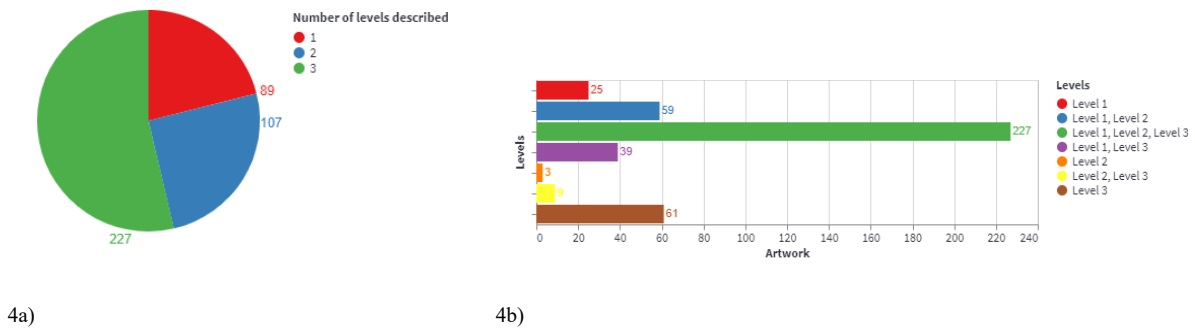
Fig. 4: a) Number of artworks having a description of one, two, or three levels; b) levels described in each artwork.

5.3.3. Iconological interpretations

The last sub-question concerns the extent to which the adopted modelling, based on Panofsky's theory, can represent his own sophisticated network of iconological interpretations. Figure 5.a shows how the distribution of supporting citations occurs according to the type of recognition. Formal Motifs Recognitions (level 1) and Iconological Recognitions equally support Iconological Recognitions.

The network of cultural phenomena (Fig. 5.b), including supporting citations and artworks cited as evidence, is highly interconnected, with an average of 1,29 edges per node. Nearly half of the artworks (200 out of 423) are included in the network, and only 10 clusters have a sole cultural phenomenon associated. On the contrary, a consistent part of the nodes is interlinked. In the bigger cluster, several important phenomena described by the art historian are connected, which are mainly devoted to the representation of classical content during the Middle Ages and Renaissance (see Table 3). Despite the artworks in this cluster being described by the art historian in different books, a connection between them is present in the data. Therefore, thanks to network visualisation, we can establish links between interpretations that are not explicitly stated in the source text. Nevertheless, some thematically related phenomena (e.g. CF1233, "reintegration of the classical astrological type with scientific and mythological antiquity"), that we would expect to be connected to the cultural phenomena cited above, do not present any connection to the cluster. In addition, although the network is highly interconnected, it is difficult to reverse it to the interpretation process made by Panofsky in the text, i.e. retrieving the exact corpus of artworks that he considered while making an interpretation (e.g. all the artworks supporting the interpretation of the iconography of *Father Time* and its evolution).
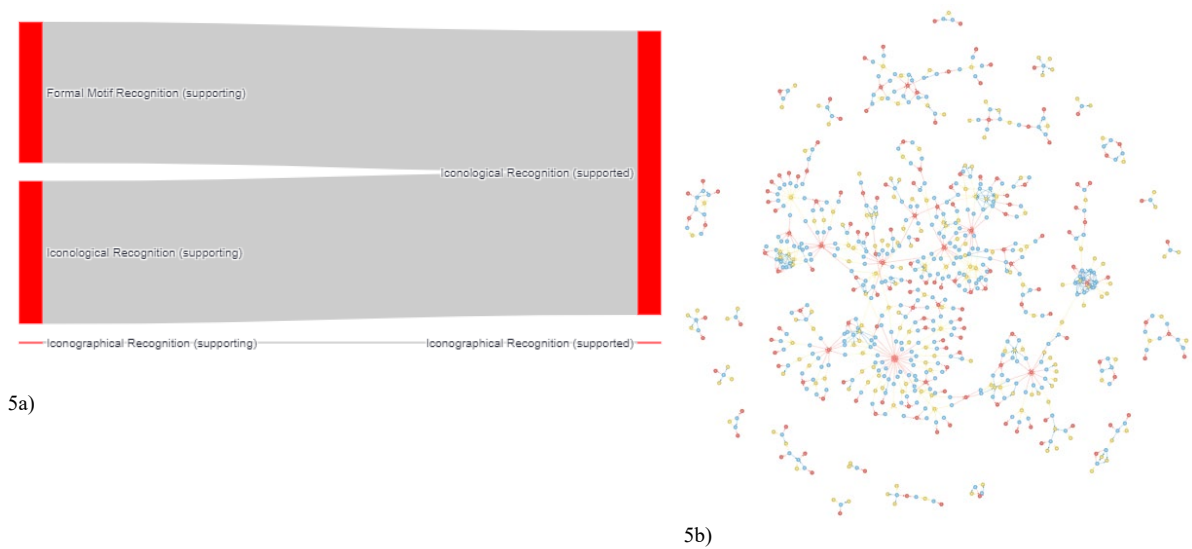
5a)

5b)

Fig. 5: a) Recognitions giving support to other ones divided per type; b) the network of iconological interpretations.

Phenomenon	Number of incoming edges
Representation of classical content with contemporary formal motifs (CF1242)	26
Iconographic evolution of classical subjects (CF1135)	13
Reintegration of classical style and content in the Italian Renaissance (CF1231)	13
Iconographic evolution of the representation of the three-headed companion of Serapis (CF1144)	12

Table 3. The most connected cultural phenomena in the iconological network.

6. Discussion

Overview. As emerged from the exploratory data analysis, the dataset created to perform this experiment can be deemed representative of Panofsky's work and of Warburg's perspective introduced in his studies, i.e. the *Nachleben der Antike*, in which the reappearance of classical motifs or themes in later cultures is traced. Therefore, our claims can be valid only considering this scope constraint.

Domain-specific research questions. It was possible to address all the sub-questions formulated for each research question, despite a quarter of them not having enough ground, due to the lack of data in our dataset. This result seems to confirm that the modelling adopted is feasible for addressing a good amount of domain-dependent research questions in a quantitative fashion.

The usage of text sources. As expected, the higher number of recognitions are of iconological nature (the third level). However, unlike Panofsky's official claim, the type of evidence mostly cited to support such recognitions is artworks and not texts. Moreover, the number of textual sources cited to support iconological recognitions is smaller than the number of those cited to support pre and iconographical recognitions. It should be noted that the high amount of cited artworks is also due to some modelling

decisions of complex cultural phenomena. Indeed, our modelling strategy consists of recording which artworks are labelled as being part of the same cultural phenomenon when the recognition of a phenomenon in a certain artwork is also the reason why the same phenomenon is identified in another artwork. To this extent, this result would require further studies. From this first preliminary analysis, data seems to contradict the criticism raised against him by scholars that claimed he was relying too much on texts when making considerations of iconological nature.

The three-layered framework of interpretation. Although Panofsky insists on the subdivision in levels of the interpretations act, it seems he tends not to explicitly make a description at all three levels for all the artworks he analysed. In fact, most artworks having a description at only one level (21%) only include the third level of interpretation. This means that the outcome of his iconographical analysis is not presented in his texts, and it constitutes the basis for an iconological recognition without being discussed, justified (nor questioned).

Iconological interpretations. The network of iconological recognitions supporting each other, citing artworks as evidence, expanded with the network of recognised cultural phenomena reveals a high interconnection and complexity. Therefore, we can claim it reflects the complexity of an iconological interpretation. Although it is not possible to retrace the single interpretation made by the art historian, the network allows us to connect multiple topics, making explicit previously hidden connections between interpretations. As a consequence, network visualisation, as well as supporting statistical graphs, can be a valuable tool for distant reading of the overall art historian's understanding of iconological phenomena.

7. Conclusion

Including an established theoretical approach in new computational methods may show some benefits, such as the extension of the study to a wider range of data. Nevertheless, an assessment of the extent to which the approach is applicable to the new practice is needed. In this investigation, the aim was to assess if the Panofskian three-layered framework of artwork interpretation is valuable when applied to semantic data and ontological modelling for 1) a quantitative exploration of the iconographical-iconological discipline itself, and 2) for characterising Panofsky's approach from the dataset of his own interpretations.

Results highlight that Panofsky's theory is valuable for iconographical and iconological analysis from a computational perspective, covering major interests in the domain. However, since the dataset describing his interpretations focuses on some core interests of the art historian, it cannot be considered representative of Medieval and Renaissance Western art, nor the results of the quantitative analysis should be read in this sense. The limited scope is also the reason why we could not fully address a few research questions.

The quantitative analysis of the art historian's interpretation led to unexpected results, which would deserve further studies to be fully understood, such as the little presence of textual sources and the limited description of artworks at all levels. Besides, the network visualisation of his own iconological interpretations shows the expected complexity embedded in iconological interpretations. The network adds further insights since it highlights connections between artworks and phenomena that are treated in separate books, otherwise difficult to detect. Limitations of the study include the manual annotation of data, which is time-consuming and prone to human interpretation and errors.

Finally, we demonstrated that the expression of Panofsky's theory from an ontological perspective is not only valuable to pursue quantitative analysis for the domain itself, but also for having insights into experts' claims, with unexpected results that can be the basis for further qualitative research. The data exploration can constitute a new perspective from which to have deeper insights into the historian's claims. The analysis can be expanded by including iconological interpretations of other art historians, so as to enable comparative analyses and exploration of networks through the competing narratives of experts' interpretations.

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