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Developing a classification model for graphic devices in early printed books

Sirkku Ruokkeinen, Aino Liira, Mari-Liisa Varila, Otso Norblad and Matti Peikola

Department of English, FI-20014 University of Turku, Finland

Abstract

This article examines visual modes of information transmission in early modern English books. Images, tables, diagrams, and other graphic devices may be used to support or illustrate the text and to communicate information difficult or even impossible to convey via words alone. Previously established models of graphic representation generally focus either on individual devices or device types, or aim to construct taxonomies of present-day materials; little has been done to combine these approaches to create historical taxonomies of visual communication. This article presents a model for classifying graphic devices in early English print, 1473-1700, based on a cross-disciplinary review of previous scholarly work on graphic and visual devices, and discusses the methodology of constructing a taxonomy of devices suitable for historical, diachronic research.

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Graphic devices; visual communication; taxonomy of images; early print; Early Modern English

1. Introduction

Graphic devices, such as diagrams, charts and tables, are used to transmit information difficult to convey through the written mode only. Situated in the grey area between textual and visual modes, these visual representations have often been disregarded in textual and philological scholarship. The Early Modern Graphic Literacies (EModGraL) project (2021–25) charts the use and frequency of graphic devices in English printed books from the beginning of printing in England in the late 1400s to 1800. This article presents a classification model developed for categorising graphic devices in early print. The classification model is the first step taken toward one of the main goals of the project: to produce a quantitative survey of the synchronic and diachronic distribution of graphic devices in early modern books of different genres and aimed for different audiences. Alongside qualitative studies on the linguistic and material contexts of graphic devices, the project aims at a comprehensive understanding of graphical representation of information in vernacular writing in this period. This article offers a critical overview of previous models for classifying graphic devices – developed for different fields – and discusses the methodology of creating our own, historically sensitive classification model.

CONTACT Sirkku Ruokkeinen siruok@utu.fi Department of English, FI-20014 University of Turku, Finland

We consider graphic devices distinct from (but intimately related to) the variety of graphic features employed in early books for pragmatic, paratextual, and decorative purposes, which have now become a standard subject of inquiry in philological studies. Such features include, for instance, the choice and use of fonts or scripts, layout, the use of colour, and decoration and illustration (see e.g. Nichols 1990; Machan 2011; Carroll & al. 2013). Many of these practices operate together and are dependent on resources available to book producers. We view graphic devices as part of the wider range of graphic and multimodal practices, explored, for instance, in the edited collection *Graphic devices and the early decorated book* (Brown, Garipzanov & Tilghman, eds. 2017).[1] In our forthcoming edited volume (Peikola, Tyrkkö & Varila, eds. In prep.), we examine a wider selection of early graphic practices alongside graphic devices to form a more comprehensive picture of the use of visual means alongside text in medieval and early modern England. With this article, we offer a toolkit for classifying instances of information visualisation in the history of English. The article thus contributes to the wider understanding of *graphic practices* in the early modern context. It also contributes to the study of the history of *graphic literacy*, the ability to read and produce visual representations of information.

We begin by discussing previous research and taxonomies of graphic devices and graphic literacy and their influence on our approach to early modern graphic devices (Section 2). In Section 3, we introduce our classification model, discussing the methodology and the application of the model with examples from our dataset. In Section 4 we present our concluding remarks.

2. Previous research and taxonomies of graphic devices

Graphic devices have been examined in various fields, including psychology, educational sciences, geography, history of science, information technology, and manuscript studies. Various taxonomies have been proposed, but while the general interest in graphic and visual representations is shared among scholars, there has been little communication across the fields (Friel & al. 2001: 125). Graphic devices have been discussed as a part of a wider interest in *graphicacy, graphic(al)/visual literacy* or *graph comprehension*. In this section, we discuss some of these approaches to graphicacy and taxonomisation.

A central question is: by which principles should graphic devices be classified? It is common to describe them from the perspective of either form or function (or structure or content), or according to the types of literary ability or cognitive processing required for the interpretation of the device. These systemic approaches may also be combined. The approach adopted in this study acknowledges the importance of literacy, especially on the macrolevel where one must consider the types of information contained by the device, but prioritises form as a starting point in the classification process (see Section 3). In what follows, we first compare the different taxonomies, from skillbased typologies to taxonomies constructed around formal or functional criteria such as structure, features, content, or meaning. After this we briefly turn to some terminological questions before discussing the few historical classification systems available.

[1]Our use of the term *graphic device* is narrower than Brown, Garipzanov & Tilghman's, (eds. 2017), and closer to Roberts & Brugar (2017), for whom the term encompasses devices communicating information but separate from the text.

2.1 Previous classifications

Graphicacy, or the ability to read and produce visual representations of information, was first conceptualised in the work of W.G.V. Balchin, Alice M. Coleman, Jacques Bertin and Edward Fry among others (Balchin & Coleman 1965; Fry 1981; Bertin 2010 [1983]; see also Danos & Norman 2009: 69–72; Roberts & Brugar 2017). In their 1965 article, geographers Balchin and Coleman argue for the necessity of teaching children to read graphs, and for positioning graphicacy among the three other central teachable skills: literacy, articulacy and numeracy. Since then, the concept of graphicacy has been applied in several contexts and studied from many perspectives, perhaps most prominently by educational psychologists. While neither Balchin & Coleman (1965) nor Balchin's later work (1996) offer a taxonomy of graphic devices, they do provide lists of examples. Balchin (1996), specifically, identifies multiple types of graphicacy necessary to read artworks, symbols, diagrams, and maps, among others.

One of the first full taxonomies of graphic devices was developed by Edward Fry (1981) within educational psychology and literacy studies. Fry's taxonomy of *graphs* – objects used for nonverbal transmission of information – proceeds from the item's form. There are six categories of graphs: lineal (e.g. timelines, storylines), quantitative (e.g. bar graphs, pie graphs), spatial (2- or 3-dimensional), pictorial (including both realistic and abstract images), hypothetical (conceptual and verbal representations of ideas, e.g. semantic maps), and omitted. The final category is reserved for those representations which may be on the borderline of graphic and other modes, but which Fry intentionally omits from his taxonomy. These include symbols, decorative designs, and arrangements which rely primarily on the verbal or numerical modes. The five other categories represent different types of *graphs* – a term which is usually used in reference to visual representations of numerical data, and which Fry intentionally uses in a broader sense, aiming to 'expand the notion of "graphness"' (1981: 390).

Later taxonomies produced in education sciences further stress the types of ability necessary to understand different visual elements. W. Danos and E.W.L. Norman (2009) reposition Fry's taxonomy in the computer age, and much like Fry's, their interest is in the communication of information through visual means. However, in creating their taxonomy, instead of formal features, they focus on the type of skill required to read the device. They provide a model with seven categories: pictorial (graphic art); pictorial (drawing); pictorial (diagrams); sequential; symbolic (quantitative/abstract); symbolic (spatial); and computer aided design.[2] They thus draw attention to the fact that visual elements may require different skills to digest the message, despite their apparent similarity. Susan N. Friel, Frances R. Curcio, and George W. Bright (2001) also approach graphic representations from the perspective of ability, but combine this approach with a closer consideration on the purpose and structural characteristics of graphs. Unlike the others discussed so far, they exclude representative images in favour of a closer examination of visual tools for representing mathematical data. Their focus is on *graphs*, in its narrower sense, or 'pictures intended to convey information about numbers and relationships among numbers' (Friel & al. 2001: 133).

[2]Danos & Norman separate computer created visualisations in their taxonomy because graphic literacy involves not only the skill to read graphic elements but also the skill to produce them (2009: 82).

Of the studies discussed so far, only Friel & al. (2001) include tables in their analysis. They acknowledge the structural similarity sometimes apparent between graphs and tables, noting that tables function not only as 'data displays' but also as an intermediary step between text and graphics (2001: 127–28). Their focus on mathematical domains of information presentation sets Friel & al. apart from other scholars of graphic devices, who often seem to exclude tables for their alphanumeric content. In other words, tables are generally considered to be in the realm of literacy and numeracy rather than graphicacy. However, as Andrew M. Riggsby (2019: 44–45) observes, the structure of a table also communicates information: it is the matrix which imbues tables with meaning, rather than individual data points within the cells. Additionally, in historical material especially, the structural features of tables may be varied and hence draw attention to the influence of visual structure in the construction of information. We return to this issue below when discussing historical classification models.

Of the models reviewed, the most comprehensive one appears to be that by Daibao Guo, Katherine Landau Wright and Erin M. McTigue (2018). Their overview of graphic devices in elementary school textbooks allows teachers to design discipline-specific teaching strategies and aid student comprehension. They term the relevant skill *visual literacy*, and define *visuals*, i.e., graphic devices, 'as graphical displays, which are not limited to diagrams, maps, graphs, and tables' (2018: 250). Much like Fry, they leave out decorative graphics that do not communicate information, but do include both images and tables in their taxonomy. Their analysis results in nine major types of visuals: photographs, general images, maps, diagrams, flow diagrams, tables, graphs, timelines, and comic strips, as well as some hybrid forms (2018: 253).

Most scholars discussed so far have influenced our thinking. Much like Balchin & Coleman and Fry, we define our focus of interest as *tools of conveying information in visual ways*. We subscribe to the widely accepted idea that different methods of representation require different types of reading ability. Yet, the more detailed categorisations in our model mainly rely on formal criteria, given that the categories of graphic devices are less fixed in historical materials, and we argue that comprehension skills cannot be approached before forming a better understanding of the range of devices. Like Guo & al. (2018) we find it necessary to include all types of devices in our classification, including representative images and tables. But our emphasis is on the transmission of information by non-textual means, and hence, Fry's (1981: 386–87) decision to rule out symbols and decoration is also applicable to our materials. We agree with his assessment of symbols as 'the equivalent of a word' (1981: 387). Decorative devices are excluded from both Fry's model and ours because they do not primarily transmit information.

While our interest here is mainly on taxonomies with a wide scope of graphic devices, we acknowledge that there is a wealth of scholarly work available with a narrower focus. Sybille Krämer (2014), for example, specifically focuses on diagrams, addressing the borderline between the diagrammatic and the illustrative categories of information visualisation. Her theoretisation of diagrams elucidates the various types, forms, functions, and information structures diagrams may take. The focus of Friel & al. (2001) on the visual presentation of numerical data targets their interest at graphs, charts and tables. The cartographer and semiologist Jacques Bertin (2010 [1983], French original published in 1967), whose focus is on *graphics* – an overlapping but wider interest in visual representation of data – studied diagrams, networks and maps. Bertin's focus is on signs whose

content a reader may not know but whose communication is conducted using a predetermined set of elements – as opposed to images, for example, whose meaning is constructed without such guidance.[3] Ioanna Vekiri's (2002) study has a similar focus. She identifies four common types of graphics: diagrams, graphs, maps and (network) charts. *Diagrams* depict the parts, structure, or functioning of concrete objects or abstract entities, while *maps* show the location or distribution of some feature in real territory using symbols. *Graphs*, such as bar graphs and pie charts, show relationships in quantitative data, and finally *charts*, such as tree diagrams and matrices, depict conceptual or sequential relationships. The two former are nonarbitrary, as their parts correspond to the objects they represent in either iconic or schematic manner, whereas the latter two are arbitrary, as the elements in graphs and charts do not correspond to the actual parts or locations of their referents (2002: 265).

Taxonomies of narrower foci have also been designed for pictures, most notably by Joel R. Levin, Gary J. Anglin, and Russell N. Carney (1987), who study the functions of pictures in prose, especially in relation to the effect of images upon information retention. They identify five types of functions. First, there is the *decoration function*, which is of ornamental purpose and 'text-irrelevant'. The *representation function* refers to images which visualise some part of the content, such as an event in the narrative. Images with an *organisation function* categorise some of the information in the text in a linear or nonlinear manner, while those with an *interpretation function* convey complex relationships in the physical world: they contain multiple parts presented in relation to one another. The example used by Levin & aL. (1987: 59) is an illustration of a bog from an ecology textbook, with trees drawn on top and layers of dirt, water and peat at the bottom, and with a key for different types of dirt below the image. Finally, Levin & al. identify the *transformation function* of images, which is seen in images designed to convey information in a memorable form, akin to mnemonics. While Levin & al.'s examination specifically targets pictures, some of the functions they identify may be considered diagrammatic, especially the interpretation function, whose purpose could easily be reframed as 'nontextual communication of information'.

We have here provided an overview of previous research into graphic devices, ranging from macro-level taxonomies to micro-level examinations of variance within a smaller set of devices. However, the studies reviewed often reflect the conventions of present-day publishing. Hence, although previous taxonomies have influenced our approach greatly, we acknowledge that they are not always applicable to historical materials. To provide depth to this discussion on taxonomies of graphic devices, we discuss some relevant historical approaches below before presenting our own model in Section 3.

2.2 Research into the history of graphic devices

Historical uses of graphic devices for transmitting information and constructing knowledge have received plenty of scholarly attention from various perspectives. Overall, two somewhat different orientations may be discerned in these studies. Firstly, the history of graphic devices may be viewed as a series of developments or trajectories evolving into

[3]See also Krämer (2014: 21–22), on this central difference between self-referential images (*Selbstbezug*) and diagrams relying on external reference (*Fremdbezug*).

present-day infographic forms and visualisations of (quantitative) data. Among the pioneering studies of such accounts of historical precursors is H. Gray Funkhouser's influential long essay in *Osiris*, tellingly entitled 'Historical development of the graphical representation of statistical data' (1937). A recent contribution demonstrating the continuity of this approach is Michael Friendly and Howard Wainer's monograph *A history of data visualization and graphic communication* (2021). As the authors observe, their volume offers 'a broad overview of how, where, and why the methods of data visualisation, so common today, were conceived and developed' (Friendly & Wainer 2021: 2). This kind of approach reminds us about the long history of graphic devices and helps explain the present. It is perhaps unavoidable, however, that some teleological thinking is involved, and that those historical devices and trajectories of change that have not directly led to present-day forms may easily be overlooked. The focus on the visualisation of statistical data also tends to mean that the late modern period and its pioneers have received a lot of attention in contrast to a more cursory treatment of earlier periods (see e.g. Hankins 1999; Wainer & Velleman 2001; Spence 2005).

The other orientation is more interested in reconstructing the use and understanding the ontology of graphic devices in their historical contexts than tracing continuities across time and identifying precursors to present-day forms. Alongside historians of science, this approach is adopted by book historians and art historians, whose work is usefully brought together in volumes such as *The power of images in early modern science* (Lefèvre, Renn & Schoepflin, eds. 2003), *Transmitting knowledge: Words, images and instruments in early modern Europe* (Kusukawa & Maclean, eds. 2006) and *The visualization of knowledge in medieval and early modern Europe* (Kupfer, Cohen & Chajes, eds. 2020). There are also monographs that address graphic devices in a specific historical period (e.g. Riggsby 2019) or specific historical graphic devices (e.g. Crawford 2019). By its very nature, this approach pays close attention to how graphic devices vary historically and how they may be individually tailored in texts to meet authors' and readers' communicative needs and expectations.

It may be surmised that of the two orientations outlined above, the first is more prone to make use of modern taxonomies of graphic devices. Thus, Friendly and Wainer (2021: 6) argue that '[w]e can sometimes come to a better understanding of the intellectual, scientific, and graphical questions by attempting a reanalysis from a modern perspective'. This position also assumes that terms and concepts used for present-day graphic devices are at least on some general level applicable to historical materials. The premise for tracing, for example, the history of mathematical tables 'from Sumer to spreadsheets' (Campbell-Kelly & al., eds. 2003) is that some fundamental formal and functional features shared by a wide variety of historical graphic attestations across several millennia allow us to define such devices as (mathematical) tables. Similarly, despite Riggsby's (2019: 44) critical assessment of some arguments concerning 'the universality of the table' in information design and cognitive science, the basic category of the *table* itself, as long as it is precisely defined, remains useful for his purposes of understanding how information was represented in the Roman world.

Adam S. Cohen's perceptive study of twelfth-century diagrammatic devices illustrates how arriving at 'hard definitions' (Cohen 2020: 387) may become increasingly difficult the deeper one engages with the plurality of devices in their textual and material contexts. Thus, according to Cohen, 'no single definition can account for the myriad permutations in

both form and function of what any medievalist might reasonably include under the classification of 'diagram' (2020: 384). Instead of proposing an all-encompassing definition for 'diagram', Cohen outlines a spectrum that runs from 'Text' to 'Image' with interim points for various diagram-like forms with increasing visuality (2020: 394). This fine-tuning arises from Cohen's thorough familiarity with twelfth-century European materials (cf. Lüthy & Smets 2009 on the historical taxonomisation of scientific imagery). While Cohen's understanding of the diagrammatic forms is enriched by contemporary meanings of the Latin term *figura*, his taxonomic terminology is essentially modern (e.g. 'Diagram', 'Diagrammatic', 2020: 394). Similarly, our taxonomy of graphic devices, while using modern terminology, builds upon our close inspection of historical materials (see Section 3.2).

3. The EModGraL classification model

Our primary materials come from *Early English Books Online* (EEBO) and *Eighteenth-Century Collections Online* (*ECCO*). While our methodology of data collection and taxonomisation is informed by previous categorisations of graphic devices, adopting a model created for modern materials would be problematic, as the conventions related to modern graphic devices had not yet been fully established in our period. Moreover, many of the models outlined above originate within the field of education or reading teaching, and the devices studied may represent a narrow selection of genres. Our work covers the whole range of early modern genres. We have therefore drawn inspiration from previous research but adapted the terminology and models for our historical data.

Our methodology is inspired by that of Guo, Wright & McTigue (2018) on visuals in textbooks. Guo, Wright and McTigue first independently classified visuals within the same book and discussed their decisions, then designed examples of definitions for types and subtypes, and finally discussed and classified a sample of visuals (2018: 251–52). The first author then classified the rest of the material, discussing uncertain or ambiguous items with the other authors (2018: 252). In our project, we first examined a selection of books from 1596 and 1696, identifying different types of graphic devices and tentatively categorising them based on their form (with some consideration for their function). Our preliminary categories were then discussed among the research team and key collaborators. Further scrutiny was ongoing during subsequent data collection phases; each team member was assigned specific years and worked on those independently, but all uncertain cases were discussed in weekly project meetings amongst the team. This method allowed us to produce a material-driven categorisation acknowledging historical variance.

In the resulting classification model, summarised in Table 1, we divide graphic devices into three main categories: General images (G), Diagrams (D), and Tables (T). General images are representational, pictorial, or symbolic illustrations that are sometimes supplemented by linguistic information. Diagrams often combine different categories of information, for example pictorial and linguistic. They represent information about objects, relationships, or processes in a schematic manner. Tables typically contain alphanumeric information organised in rows and columns. In addition to these three categories, we have a fourth category for unclear and hybrid cases (U), to account for items not clearly belonging to the other categories due to historical sensibilities, damage, or structural overlap. We will introduce each category and its subcategories in more detail below.

Table 1. Classification of graphic devices.

G	General image	G	General image
		Gt	General image with text
D	Diagram	D	Diagram
		Da	Arithmetic notation
		Db	Braces
		Dn	Musical notation
T	Table	Ts, Tm, Tl	Table (small, medium, large)
		Tc	Calendar
U	Unclear	U	Unclear
		Ut	Unclear table

Before delving into the details of the classification, it is important to acknowledge our general principles of practice and positions adopted in the analysis. Firstly, we recognise that our categorisation is not a universal model for classifying graphic devices. Rather, it is a historically sensitive classification for materials produced using the newly adopted technology of print.

Secondly, graphic devices can be classified following either formal or functional criteria. A form-based approach allows us to observe larger datasets; analysing both the context and content of each individual graphic element would be almost impossible in a dataset of tens of thousands of devices. We use a top-down approach, starting from sampling the data and developing working definitions for each type of graphic device, then modifying those definitions where needed. We focus on prototypicality, discussing, for example, the minimum requirements for a graphic device to be considered a diagram or a table, to account for the fact that forms of graphic devices developed during our period.

Thirdly, we exclude several categories of material from the study based on a previously formed understanding of early printing and textuality. We thus leave out paratextual elements such as title pages, frontispieces, indices, tables of contents, errata lists, and printers' devices. Although these elements may contain illustrations and tables, paratexts have distinct interpretive, commercial or navigational functions, guiding the reader in the interpretation and use of the text (Birke & Christ 2013). Paratexts (such as title pages and prefaces), and the graphic devices within, communicate messages largely different from those which appear among the main text of the book. In addition to paratext, following Fry (1981) and Guo, Wright & McTigue (2018), we exclude primarily decorative elements such as borders and vignettes. Our assessment of these features as primarily decorative is informed by earlier research in book history, bibliography and art history. The elements are produced using pieces from a printer's existing stock, and are usually interchangeable. Although these kinds of graphic elements may have pragmatic functions such as helping the reader spot textual divisions (Carroll & al. 2013; Liira 2020: 158–200), we do not consider them graphic *devices* which exist to transmit knowledge. However, in some cases the boundary between, for instance, a decorative border and an illustration, and sometimes even between text and paratext, may be rather fuzzy, and such cases have been discussed among the research team.

Finally, we exclude five additional types of elements: lists, dictionaries, linear and interlinear glosses, mathematical notation limited to one line of text, and linear use of symbols such as astrological signs. Their linear nature is key to their exclusion: the reader moves from left to right (or right to left), sometimes also from line to line. The reading progresses systematically, and no significant additional information may be gleaned from organisational structures or relationships between elements. Similarly, we have left out lists even when their layout resembles tables (see 3.4.1), and the inclusion of mathematical notation only applies to those elements whose structure is more complex than that of a one-line mathematical notation (see 3.2.1). Dictionaries and glossaries are also excluded for their list-like structure, as are alphabetical indices. Although dictionaries and indices may resemble a table by layout, they do not fulfil our criteria for tables (cf. Section 3.3). We discuss the categories of devices in more detail through examples below.

3.1 General images

The category of *General images* (G) covers representational, pictorial, and symbolic illustrations. While our project is mainly interested in graphic devices constructed for presenting information – such as tables and diagrams – we see value in also including illustrations in our model. Illustrative images, too, convey information, although perhaps of a different kind. Indeed, images and illustrations have often been included in previous taxonomies of graphical representation and graphicacy (e.g. Fry 1981; Danos & Norman 2009; Guo, Wright & McTigue 2018). Given that it is not always simple to distinguish between illustrations and diagrams in general, let alone in this early period of printing, the inclusion of illustrations allows for a more critical view of the continuum from representational illustrations to schematic diagrams. Additionally, including illustrations allows us to have a point of comparison for our quantitative survey and the use of diagrams and tables. We may track the popularity of different types of visual representations in different genres, and at different points of the early modern period.

We divide images into the main category G and one subcategory, Gt (*General images with text*). The latter includes illustration with textual elements such as linguistic, symbolic, or alphanumeric annotation. Images which contain such elements may resemble diagrams or have functions different from images without textual elements; the subcategory allows us to explore the potential differences. Textual elements may vary from single letters to lengthier passages; however, the text must occur within the image area. During this early period, the distinction between captions and other kinds of image-related text (such as titles, running titles and other metatext) is not always clear, and determining the specific relationship between the image and text would often necessitate further analysis of the page. Therefore we only include items where text appears within the image.

Items classified as G or Gt may depict, for instance, people, animals, cities or other physical entities of the natural world. They can also be symbolic or emblematic images such as coats of arms, as well as shapes or models for different crafts or professions (cf. Figure 3 further below). Devices in categories G and Gt may provide visual stimuli, but they are also used to convey information, such as to clarify the exact shapes of tools or other physical objects, illustrate events, or create structure within the text. In William Caxton's second edition of Chaucer's *Canterbury tales* (STC 5083, [1483]), for example, woodcut images are used to signpost significant narrative events – the introduction of

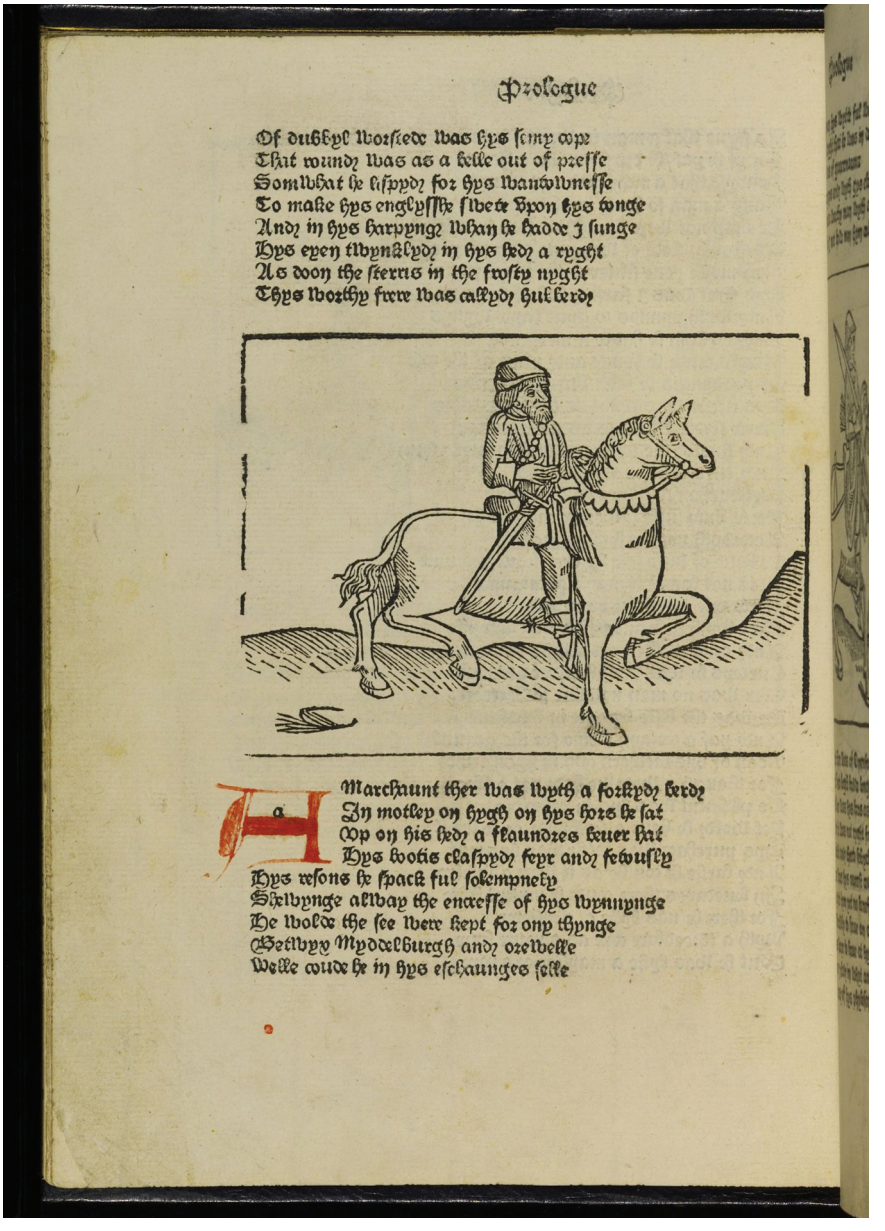


Figure 1. STC 5083. Chaucer, Geoffrey, *Canterbury tales*. London: William Caxton, [1485?], a8v. <http://access.bl.uk/item/viewer/ark:/81055/vdc_100054605479.0x000001>. Public domain.[4]

new pilgrim characters – and for text-organising purposes. In Figure 1, the rider on horseback signals the introduction of the Merchant in the General Prologue.

In STC 5083, most woodblocks are used twice, first in the General Prologue, then in the corresponding tale. This way, a set of 23 woodcuts is used to produce 47 images within the edition. This 'index-like function', as David R. Carlson (1997: 28) calls it, is not fully systematic, as Caxton occasionally uses the same image to illustrate more than one tale. For example, the 'merchant woodblock', seen in Figure 1, is used five times, to illustrate

the tales of the Merchant (a8v; l8r), the Franklin (b2), and the Summoner (c1v; t6v). This is enabled by the lack of identifiable features which would suggest a specific profession. The decision of producing woodblocks of indistinguishable characters was a sensible economic decision, as the images reappear several times in Caxton's and his successors' editions (Carlson 1997: 29). Indeed, Caxton's use of woodcuts highlights a crucial feature of the category of general images: flexibility in the use of the image within the text or even within several different texts.

In terms of structural characteristics, the images in the *Canterbury tales* provide a fairly simple and prototypical example in both form and content. The image is clearly separated from the surrounding body text and thematically connected to the text. The images have clear, square borders, and they appear at the maximum frequency of one per page. All of these details simplify the classification significantly. Not all early modern use of illustration is as neatly structured, however, and different production methods introduce various challenges for the classification. Some images are placed within the main text area, a practice which mostly occurs when images are printed from woodblocks and can be set along with the text. These are usually rather simple illustrations, and appear, for instance, in utilitarian texts and guidebooks, such as Robert Boyle's *Some considerations touching the usefulnesse of experimental natural philosophy* (Wing B4030, 1671, see 2Q1). Engraved images printed from copper plates typically appear on separate leaves and sometimes on larger foldouts (see, e.g., Anon. [Michael Sparke], *Crvmvs of comfort and godly prayers*, Wing S4817A, 1671). Such plates may be bound amidst the regular leaves or at the beginning or end of the book. For example in copies of medical texts, such as Jean Riolan's *A sure guide, or, the best and nearest way to physick and chyrurgery* (Wing R1526, 1671), the images may be found bound at the end. The technology of production thus affects the placement of images in relation to the body text, and also the clustering of images (or diagrams), as it may have been simpler to produce several images on the same plate.

3.2 Diagrams

The category of *Diagrams* (D) covers graphic devices which convey information on relationships or processes, as well as schematic images of objects. Diagrams differ from illustrations mainly in that they are not simple visualisations but serve as 'tools for thinking', not only structuring information but also constructing it (Krämer 2014: 14). We subscribe to Cohens's (2020) conclusions about the necessity of engaging with the plurality apparent in diagrammatic representations of information, but the nature of classification schemes itself necessitates some taxonomic thinking. The items found to be at the intersection of categories have been classified as Unclear (see Section 3.4. below).

One of the more straightforward types of diagrams is geometric diagrams. These are constructed using lines and curves, crafted in patterns of circles and angles. They are found in scientific or mathematical books, including applied mathematics. Characteristic examples of such diagrams are found, for instance, in treatises on sundials and other instruments for dialing, which were fashionable in continental Europe from the late

[4]ESTC identifies the publication year as [1483].

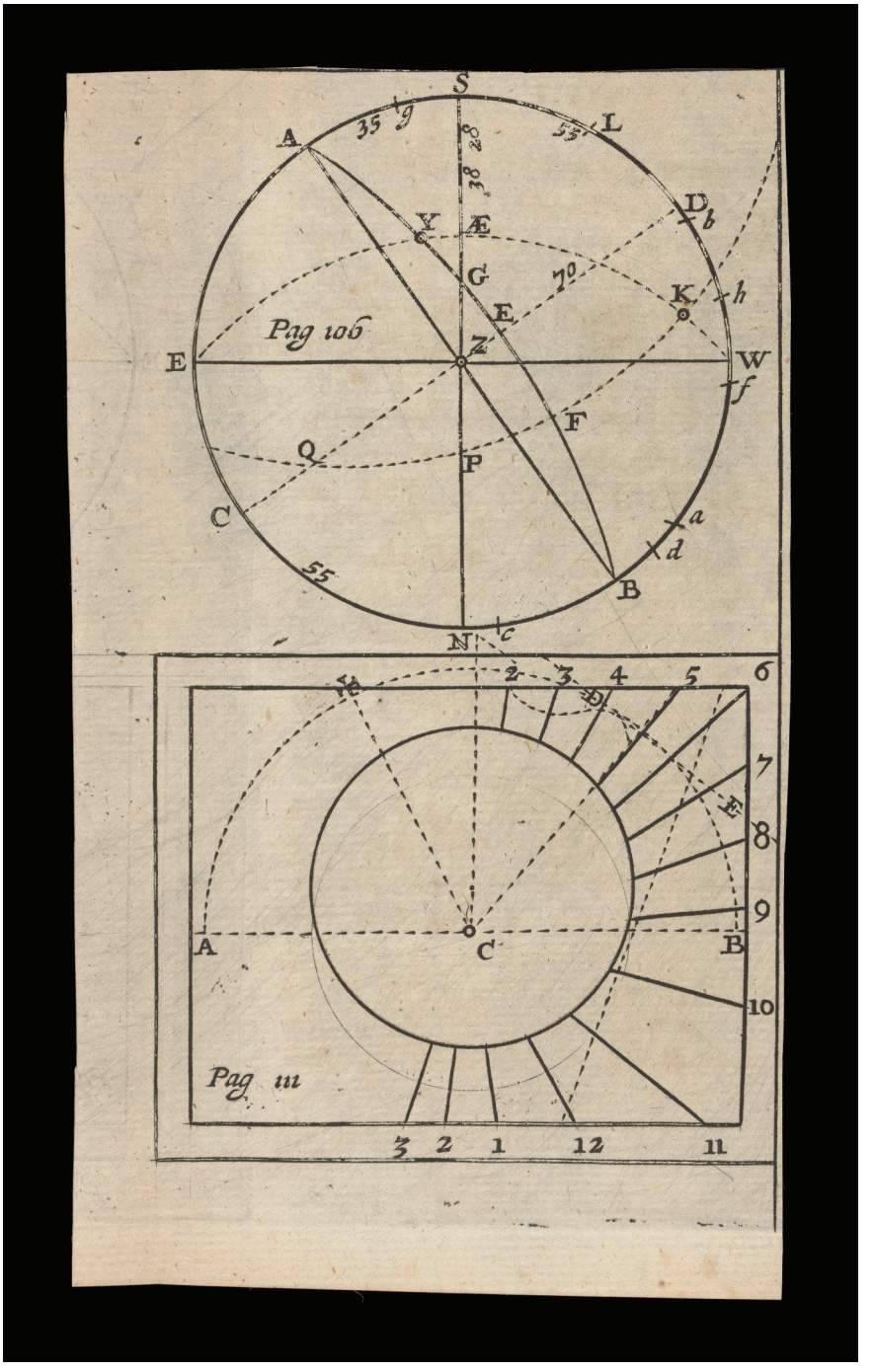


Figure 2. Wing B5042. Brown, John, *Horologiographia*. London: printed by John Darby, for John Wingfield, 1671. A loose leaf of images marked p. 106 and 111. Wellcome Collection.

fifteenth century onwards (Jardine 2020: 115). By the late seventeenth century, several works on the topic had also been published in English. John Brown's *Horologiographia* (1671, Wing B5041–B5042) describes practical and theoretical uses of a triangular quadrant in calculations relating to astronomy and navigation. The diagrams in this work (see. Figure 2) are fairly technical, intended for a professional reader comfortable with the level of mathematical thinking required to make use of the schematic representation.

The diagrams in Figure 2 help illustrate the building of sundials in a recline or a slope, and the practicalities of drawing the dial itself. The second volume of Brown's *Horologiographia* contains over 40 similar diagrams, printed on loose leaves to be cut and pasted into appropriate locations within the volume.

Other typical diagrams include maps and plans, genealogical charts, and representative figures of humans, animals or objects conveying anatomical or structural knowledge. Often appearing as part of medical, biological or other scientific works, such devices typically explicate the relationships of parts in a complex system (such as a skeleton or a family tree). All these types commonly combine alphanumeric information with pictorial or schematic elements.

Diagrams thus differ from general images in their schematic nature: their primary meaning comes from the positioning and relationships of their constituent parts. However, it is sometimes difficult to distinguish diagrams from general illustration. Consider, for example, the models for shaping pie in John Shirley's *The accomplished ladies rich closet of rarities* (1696, Wing S3501), which we classify under Gt rather than D (see Figure 3).

At first glance, the shapes in Figure 3 are simple line drawings without artistic finesse (such as shading) typical of images. However, these shapes do not depict a pie as such, nor are they decorative. They illustrate appropriate shapes for certain types of pies (e.g. 'Carp Pie', 'Goosbery-Tart' and several shapes for 'Custard' pies), and hence convey information and instruct the reader through visual means. Generally, images that contain patterns or models are not included in the category of diagrams in our classification, unless they explicate the relationships (e.g. measurements) of an object or label its parts (cf. anatomical illustrations). Thus, the pie illustration in Figure 3 is placed in Gt because it represents individual examples rather than parts of a whole. All in all, it is with the gradual addition of schematic features (e.g. tie marks, lines, scales, symbols) and/or reduction of artistic detail (e.g. depth, shading) that the illustrative elements slide on the scale towards diagrammatic modes of representation. Sometimes a decision has to be made on which features are the most salient. When a device is especially complex in this regard, we consider it a hybrid (classified as Unclear, see Section 3.4).

In addition to the general category of diagrams, we discern three subtypes of diagrams: arithmetic operations (Da), braces (Db), and musical notation (Dn). Separating these from the main category of D is important for the purposes of our future quantitative studies, given that some of these subtypes are highly concentrated within certain genres and could skew the results. For example, the subcategory Dn comprises staves, tablatures and other systems of representing sound mainly found in psalm books and other publications in the domain of music. There are no particular challenges pertaining to Dn, and hence we do not discuss it here further. However, the special properties of Da and Db are briefly discussed below, as these subcategories are less straightforward.

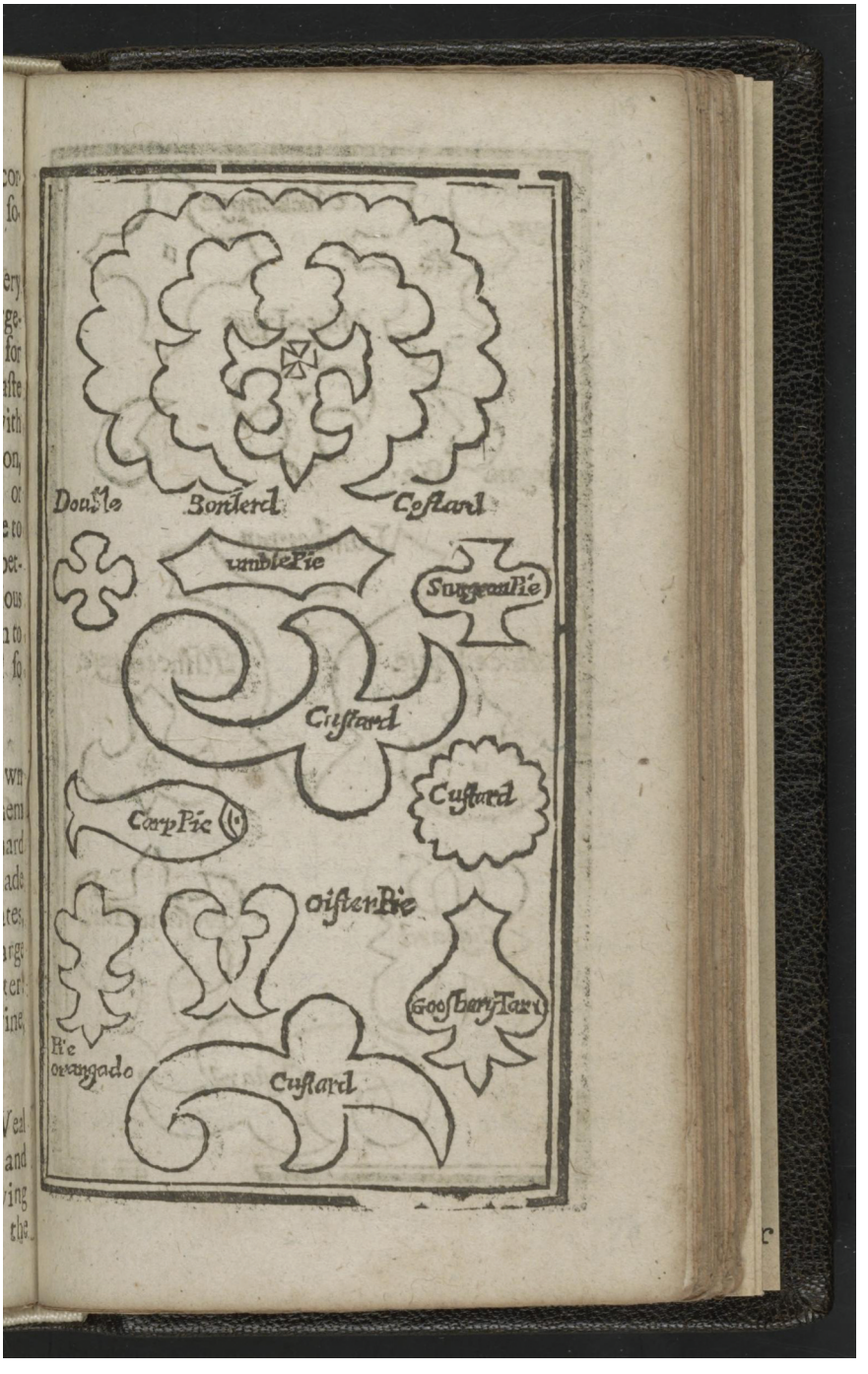


Figure 3. Wing S3501. Shirley, John. *The accomplished ladies rich closet of rarities* […]. London: W. Wilde for N. Bodington and J. Blare, 1696, p. 115. Elizabeth Robins Pennell Collection, Library of Congress, Rare Book and Special Collections Division. [Pdf.] Retrieved from the Library of Congress, <www.loc.gov/item/73176765/>.

3.2.1 Arithmetic operations

The subcategory *Arithmetic operations* (Da) comprises arithmetic or algebraic notation using numbers or other systems such as counters. The category only includes mathematical notation in a diagrammatic form, or consisting of multiple lines, usually set apart from the body text. Single-line mathematical notations are excluded. Geometric devices, which often co-occur with mathematical notation, are placed under the main category of diagrams. Arithmetic operations may primarily be found in educational books: mathematics and economics are perhaps most prominent, but Da is also prevalent in genres such as music, navigational or military manuals, and astronomical works.

Sometimes it is difficult to determine whether a device should be classified under the main category of diagrams or the subcategory Da. This is primarily seen where early modern mathematical manuals include visual elements in their didactic prose and accompanying calculations. For example, *Records arithmetick* (1646, Wing R650)[5] includes large diagonal crosses, typically with four numbers, one in each corner. These are called St. Andrew's Crosses, and they are used to exemplify the processes of multiplication and division (p. 70; cf. Figure 4). Notably, however, the X-shape is not meant to signify a cross *per se*, but two crossing lines. Each line connects two numbers which are to be used in the calculation (see Cajori 1993: 253). Horizontal zig-zag patterns are employed to exemplify different types of arithmetic progression (p. 142), and oversized Z's and slashes are used to guide the reader through simple equations (p.182–183; cf. Figure 4) (for Recorde's notation, see Cajori 1993: 164–167).

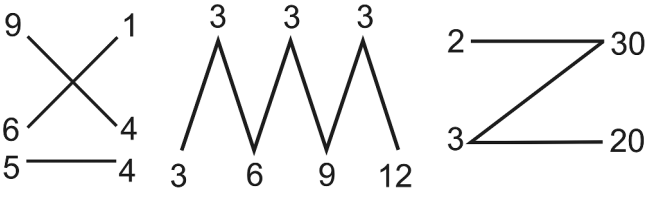


Figure 4. Schematic illustrations of arithmetic notation.

Such visual elements are not regarded as separate diagrams in our model, but rather as part of the mathematical notation – symbols on par with signs of addition and subtraction. Yet, it must be recognised that they do hold diagrammatic and not only symbolic properties: they rely on visual means of representing information, indeed, almost physically directing the reader's attention when moving through the mathematical notation on the page. Nevertheless, these visual representations are considered part of the arithmetic notation, given that their existence is dependent on the calculation they appear within.

[5]Robert Recorde's *Arithmetic, or the ground of arts* was first published in 1543 (STC 20797.5), and appeared in many subsequent editions, augmented, like the 1646 edition, e.g. by John Dee and John Mellis.

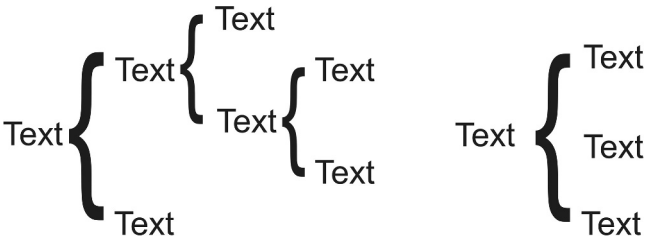


Figure 5. Schematic illustration of braces in a tree-diagram (left) and to group items (right) .

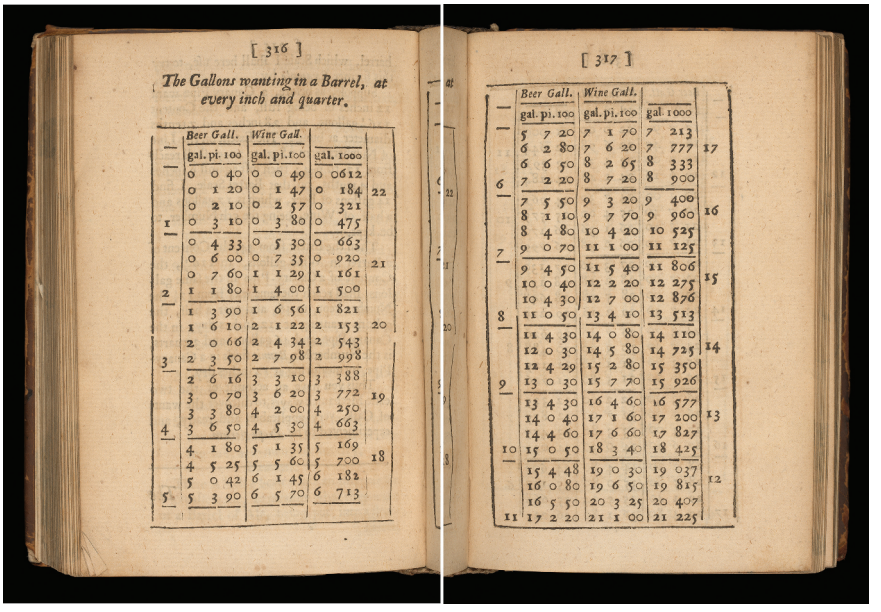
3.2.2 Braces

Braces, groupings of braces, and devices constructed using braces, are classified into a separate subcategory, Db (*Diagram: braces*). Braces, or curly brackets, have a long and complex history as a method of structuring information. The most prominent use of braces for information structuring occurs in horizontal or vertical tree-diagrams (cf. Figure 5, left), where braces are used to make connections and to express dependencies between elements. The tree-diagram was a popular pedagogical tool in the early modern period due to its summary format (Blair 2010: 145). It should be noted that the history of the tree-diagram predates the use of printed braces (see Even-Ezra 2021, esp. 9). Indeed, tree-diagrams can be constructed without braces, for example by using lines; in such cases, we have classified the items as D rather than Db, following strict formal principles despite their similar function and conceptual category. Single braces, too, can be used for information structuring, for example to group items or lines of text together (cf. Figure 5, right). Such is often the case in character lists of plays, where characters of the same family or profession are linked (e.g. Thomas Middleton, *Honorable entertainments compos'de for the seruice of this noble cittie*, STC 17886, 1621). Braces may also be found in grammars and primers, grouping together e.g. inflections or syllables, as in Edmund Coote's *The English schoole-maister* (STC 5711, 1596, B1v and B3r). Sometimes braces also mark rhymes in verse (cf. Sawyer 2020: 123–43 on rhyme braces in late medieval English manuscripts).

We do not view all uses of braces as schematic. Braces also have decorative purposes, when used, for instance, to cradle page numbers or marginalia (see e.g. Thomas Shepard, *The sincere convert discovering the small number of true beleevers*, Wing S3120, 1646). However, distinguishing between decorative and information-structuring functions would require extensive study into the history of braces and tree-diagrams – much of which remains uncharted – and careful context-specific analysis of each token. Hence our approach to braces is strictly formal: all uses are included.

3.3 Tables

The category of *Tables* consists of graphic devices that derive meaning from organising alphanumeric or pictorial information into regular structures of rows and columns. The rows and columns may or may not have labels, and the individual cells may be formed by either rules or by whitespace. Some cells may be left empty. Although our approach generally progresses from form, the key constituent here is the meaning a table derives from its structure: the extra information provided by the 'cross-cutting' of the categories of information in the rows and columns (Riggsby 2019: 45).



[316]

The Gallons wanting in a Barrel, at every inch and quarter.

	Beer Gall. gal. pi. 100	Wine Gall. gal. pi. 100	gal. 1000	
	0 0 40	0 0 49	0 0612	
	0 1 20	0 1 47	0 184	22
	0 2 10	0 2 57	0 321	
1	0 3 10	0 3 80	0 475	
	0 4 33	0 5 30	0 663	
	0 6 00	0 7 35	0 920	
	0 7 60	1 1 29	1 161	21
2	1 1 80	1 4 00	1 500	
	1 3 90	1 6 56	1 821	
	1 6 10	2 1 22	2 153	20
	2 0 66	2 4 34	2 543	
3	2 3 50	2 7 98	2 998	
	2 6 16	3 3 10	3 388	
	3 0 70	3 6 20	3 772	19
	3 3 80	4 2 00	4 250	
4	3 6 50	4 5 30	4 663	
	4 1 80	5 1 35	5 169	
	4 5 25	5 5 60	5 700	18
	5 0 42	6 1 45	6 182	
5	5 3 90	6 5 70	6 713	

[317]

	Beer Gall. gal. pi. 100	Wine Gall. gal. pi. 100	gal. 1000	
	5 7 20	7 1 70	7 213	
	6 2 80	7 6 20	7 777	17
	6 6 50	8 2 65	8 333	
6	7 2 20	8 7 20	8 900	
	7 5 50	9 3 20	9 400	
	8 1 10	9 7 70	9 960	16
	8 4 80	10 4 20	10 525	
7	9 0 70	11 1 00	11 125	
	9 4 50	11 5 40	11 806	
	10 0 40	12 2 20	12 275	15
	10 4 30	12 7 00	12 876	
8	11 0 50	13 4 10	13 513	
	11 4 30	14 0 80	14 110	
	12 0 30	14 5 80	14 725	14
	12 4 29	15 2 80	15 350	
9	13 0 30	15 7 70	15 926	
	13 4 30	16 4 60	16 577	
	14 0 40	17 1 60	17 200	13
	14 4 60	17 6 60	17 827	
10	15 0 50	18 3 40	18 425	
	15 4 48	19 0 30	19 037	
	16 0 80	19 6 50	19 815	12
	16 5 50	20 3 25	20 407	
11	17 2 20	21 1 00	21 225	

Figure 6. Wing B5041. Brown, John. *The description and use of the trianguler quadrant*. London: printed by John Darby, for John Wingfield, 1671, p. 316–317. Wellcome Collection.

The table illustrated in Figure 6 is a typical example. The Figure contains the first two pages of a six-page table which demonstrates the volume conversion of beer pints, wine pints, and gallons, tracking both the liquid drawn and remaining (John Brown, *The description and use of the trianguler quadrant*, 1671, STC B5041).

Figure 6 illustrates several features we consider typical of a table: the organisation of information in lines and columns, with specific types of information intercrossing in cells. The reader may move within the table both vertically or horizontally. There are column labels, and the ruled cells create a grid. The information in the table is numerical and forms a thematic whole. However, not all columns have labels, and not all cells are ruled. These features of the table are accepted as optional.

Tables have some significant overlap with some other categories of information structuring, most notably lists. Although lists may sometimes occur in a seemingly tabular format, we do not consider these to be tables unless they consist of more than one column and row of data and derive meaning from the intersection of the columns and rows. Issues such as irregularity in the information content may also complicate classification. Some cells may, for example, contain more types of information than others in the same category. Some tables may be constructed using braces, which leads to the question whether the braces or the table structure should be the determining factor in the classification. To accommodate this plurality, the devices that contain table-like features but do not quite fulfil the definition are classified separately as Ut (unclear table-like devices). We discuss these in Section 3.4.1.

To gain a more finetuned understanding of early modern tables, we divide them into four subcategories. Calendars have their own subcategory (Tc). All other tables are divided according to the size of the item: Ts (*Table: small*) refers to tables that contain 25 cells or

fewer, Tm (*Table: medium*) to those with 26–100 cells, and Tl (*Table: large*) to those with more than 100 cells. While these ranges are somewhat arbitrary, distinguishing between differently sized tables allows us to trace developments across the long diachrony and see if larger tables, for instance, become more common toward the end of the period.[6]

Calendars (Tc) form a special group of tables. As with the diagram subtypes, coding calendars separately from other tables gives us a more accurate picture of the distribution of devices between genres. Calendars habitually appear in almanacs, but may sometimes also be found in other contexts, such as in the *Book of common prayer*. The primary purpose of the calendar was time keeping, to observe religious feasts and other significant days during the liturgical year, but several sub-genres, or specialisations, primarily medical and astronomical in nature, were developed during the early modern period (Peikola & Varila 2023: 93–94). Calendars are most often found as a series of monthly tables, spanning several pages.

3.4 Unclear cases (U)

The majority of the devices can be classified into the three main categories relatively easily. However, in the working stage our classification model has a separate category for *Unclear cases* (U), mostly consisting of different types of hybrid elements. Category U also contains devices that fall outside our categorisation altogether, i.e, are truly unclear until they can be analysed in more detail, and items which cannot be categorised due to damage, loss, or poor image quality. U has one subcategory, *Unclear tables* (Ut), which contains devices that have some properties similar to tables but do not fulfil the criteria (see Section 3.4.1 below). Devices tentatively categorised as Unclear will not be included in our later quantitative surveys, unless they are reclassified in one of the three main categories as a result of closer analysis.

One common type of Unclear items consists of hybrids: devices which contain characteristics of more than one category of graphic devices. In Peter Heylyn's *A help to English history* (London, 1671; Wing H1718), for example, images of coats of arms are inserted between a chronological table listing noble houses and title-holders, interrupting the tabular structure. A more complicated type of hybridity may be seen in the device depicting the Wheel of Fortune in Samuel Strangehopes's *Book of knowledge* (London, 1696, Wing S5928) , shown in Figure 7. The figure shows an example of a device which we consider to have illustrative (and symbolic), tabular, and diagrammatic properties. Tabular, numeric information is contained within the wheels of good and bad fortune, formed of the ouroboros symbol of a dragon biting its tail in the shape of the number 8. The double wheel is surrounded by illustrations of the sun and moon, as well as two figures reminiscent of diagrams, all contained within single borders.

Finally, the category of Unclear devices includes some truly puzzling items. First printed in 1485 by the anonymous St Albans printer, *The St Albans chronicle* (STC 9995) and its subsequent editions, including Wynkyn de Worde's editions of the *Chronicles of England*, contain several graphic elements found primarily at section heads. They consist of squares, concentric circles (medallions), decorative elements, and text set inside the medallions as well as running around the square. The medallions generally bear

[6]The size of a table may also depend on material factors such as the format of the book.

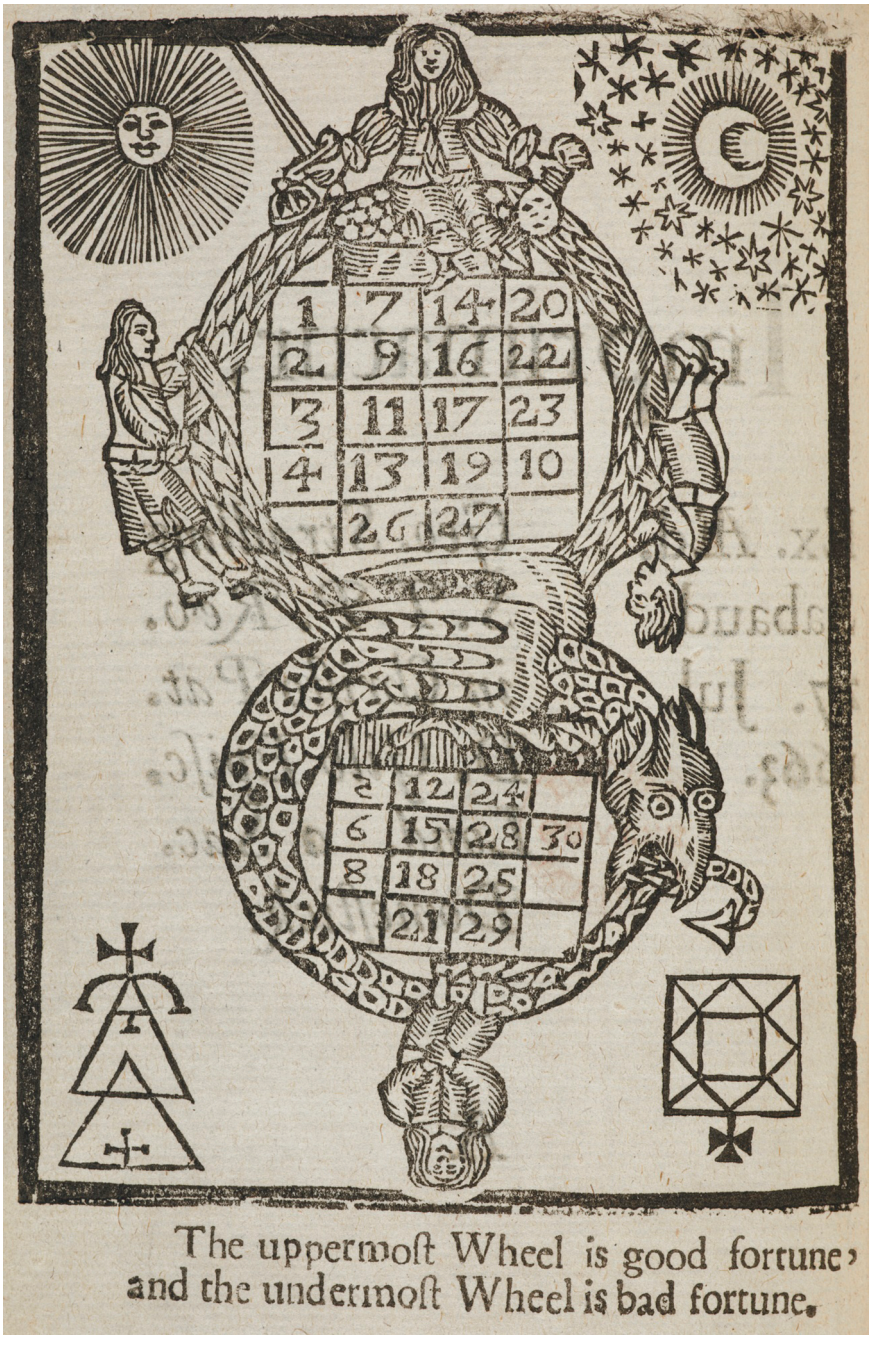


Figure 7. Wing S5928. Strangehopes, Samuel. *A book of knovvledge*. London: printed for J. Deacon, 1696, A1v. © British Library Board (shelfmark 8610.aa.40). Reproduced by permission.

genealogical information and they function as section titles or summaries of the topic of the text following.

The device in Figure 8 begins the section on the Norman conquest. The rubric reads '¶How Wyllyam Bastarde duke of Normandye came into Englande/and slewe kynge

Figure 8. STC 10001. *Saint Albans chronicle*. London: Wynkyn de Worde, 1520. British Library shelfmark: C.194.b.430. Public domain.[7]

Harolde'. Enclosed in the medallion is the rubric 'Wilhelmus conquestor', and the text set around the device reads '¶Here come Normans | and expulsed Ha|rolde a Saxon'. Similar devices are found at other section heads. These devices contain floral decoration in the corners, but the items are not primarily illustrative or decorative. The text of the section heading derives no additional meaning from being placed in the elaborate configuration, and the geometric structure does not immediately communicate any extra meaning, aside from association with certain graphic conventions. A possible inspiration for these devices may be Werner Rolevinck's fifteenth-century chronicle *Fasciculus temporum*, which connects the devices to the tradition of constructing genealogical charts and timelines (Driver 2004: 49; on Rolevinck, see Ingham 2018). The rectangular shape may also echo a popular Aristotelian diagram type, the square of opposition (e.g. Murdoch 1984: 62–71). However, further study would be required to understand the full meaning of the device. Although these graphic elements are sometimes referred to as diagrams (e.g.

Driver, ibid.) they neither fall into our category of Diagrams nor the categories of General images or Tables. We would, however, hesitate to dismiss them as purely decorative (i.e., not 'graphic devices'), due to the connections to diagrammatic traditions. The category of Unclear is a work-economic solution that allows us to include such elements in our data without having to conduct deeper contextual analysis at the data collection stage.

3.4.1 Unclear tables (Ut)

Our dataset contains several examples of devices which contain tabular properties but cannot be unambiguously classified as tables. We have tentatively categorised these as *Unclear tables* (Ut). Devices in this subcategory will be examined in a separate qualitative study (Liira & Scase *In prep*.). What these devices have in common is that they may fulfil some of the criteria for tables but not all of them. For instance, their cell structure may be irregular, or they may contain only two columns. We do not count lists as graphic devices, even if these appear in several parallel columns, since the mode of reading is linear. While numbered lists technically have two columns, they only have one category of information: the numbers may provide a reference point but they mostly reinforce what the order of the lines already communicates. However, lists and tables seem to form a continuum (see e.g. Robson 2003 who discusses ancient Sumerian, Babylonian and Assyrian tables).

To aid our data collection process, we formulated the following working definition for 'unclear tables': these devices have text laid out in two or more columns, with or without labels, clearly separated by whitespace but with no clearly identifiable cells. Simple numbered lists are excluded, but it is not uncommon for these elements to have a third column for running numbering, which highlights the fuzziness between tabular devices and lists. It is possible that in most cases we are dealing with multi-column lists which are 'graphically tidied up' (Riggsby 2019: 47), but there also appears to be other kinds of overlap involved. Fuzziness can also be created through hybridity between tables and diagrams, for example (for the close relationship between medieval tables and diagrams, see Wallis 2015, esp. 19–23).

4. Concluding remarks

In this article we have introduced a classification model for early printed graphic devices, i. e. tools for information visualisation. In Section 2 we conducted a literature review of modern taxonomies of graphic elements and some major studies on historical graphic devices. Section 3 focused on our methodology of devising a functional categorisation for historical materials and discussed its application.

Our categorisation is intended as a methodological tool, developed specifically for wide-scale quantitative research of early modern graphic devices during the handpress period. The classification is, by necessity, primarily form-based, since a function-based classification would require deeper inquiry into each specific token in its textual, linguistic and material context. Nevertheless, we consider form and function intertwined, which is why we have opted to collect data manually. Some consideration for function was necessary, for instance, to rule out decorative and paratextual elements. Similarly, while

[7]Accessed through British Library blog, https://blogs.bl.uk/untoldlives/2020/03/a-full-house-of-brut-english-chronicles-.html.

we made the decision to exclude symbols from our data, small one-line diagrams – which were found to function similarly to larger diagrams – were included.

To recapitulate, we acknowledge that understanding early graphicacy requires careful context-specific analysis, and that modern terminology cannot be anachronistically applied to historical materials (cf. Lüthy & Smets 2009: 400, who raise important points regarding the problems of taxonomisation). Yet, an attempt to avoid all anachronism would make it impossible to create a functional classification model, especially considering the fairly long diachrony and the wide range of genres represented in our materials. We have aimed to alleviate the problem by the macro-level categorisation introduced above: categories that are broad enough to allow for diachronic and synchronic variation, yet well-defined enough to make such classification meaningful. Our future studies will focus on both qualitative and quantitative points of interest revealed in the classification process. During the collection process, questions were raised, for example, with regard to tables and table-like structures, the status of braces, and the material and linguistic representation and framing of graphic devices. In the future, we will utilise the classification both in qualitative analyses and quantitative reports on the frequency and use of graphic devices in different genres.

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Notes on contributors

Sirkku Ruokkeinen is a postdoctoral researcher in the EModGraL project at the University of Turku.

Aino Liira is a postdoctoral researcher in the EModGraL project at the University of Turku.

Mari-Liisa Varila is a lecturer in English at the University of Turku.

Otso Norblad worked as a research assistant and project researcher in the EModGraL project.

Matti Peikola is professor of English at the University of Turku.

ORCID

Sirkku Ruokkeinen http://orcid.org/0009-0007-9497-5173
Aino Liira http://orcid.org/0000-0002-4766-802X
Mari-Liisa Varila http://orcid.org/0000-0002-2930-0854
Matti Peikola http://orcid.org/0000-0002-9004-8926

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