Classification and visualization of knowledge. Light from a forgotten past

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Abstract

This paper is based on an ongoing project to investigate how knowledge has been visualized in different times and places. Its focus is on how, over the fourth to the sixteenth centuries in Europe, literate societies used mental images to support memory in visualizing and classifying the knowledge embodied in texts, in order to make it part of their own knowledge store, to organize it for retrieval, and finally to create and communicate new knowledge.

In this paper I:
- define information and knowledge and their visualization, and propose a model of their relationship and the processes involved;
- identify critical stages in the interaction between humans and technologies to support these activities;
- note close analogies between earlier practice and what would today be termed information design;
- suggest the relevance of these ideas and practices to today's problems of organizing and communicating knowledge, and propose some practical approaches to making use of them.

Introduction

This paper sets the topic in the context of how and why human beings have visualized knowledge at different times and in different places. It is part of a larger project that began because much of the current literature on 'knowledge visualization' seemed to treat it as a problem to be solved exclusively in the domain of computing. This differed from my own way of looking at the subject, so before going further, these are the definitions of the relevant terms used in this paper. [1]

Definitions

Information and Knowledge
Information is what we seek and pay attention to in our outside world when we need to enrich our *knowledge* in order to act upon it. When we find useful information, we *transform* it into knowledge stored inside our minds, which we use to guide our actions and interactions with the outside world. When we want to *communicate* what we know to others, we have to make it *visible or audible* to them, by transforming it and putting it into the outside world, in the form of Information. (Definition based on Orna and Stevens, 2009, p. 14)

Visualizing information
Eye and brain take in from the outside world information of potential value for us. We use 'inner visualization' to interpret its meaning and make it part of our own knowledge.

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[1] These definitions of information and knowledge and the idea of transformation used here have a foundation in the literature of information science going back to Brookes (1980a, 1980b) and Farradane (1980) and continuing in the work of such authors as Marchand, Kettinger & Rollins (2001a, 2001b) and Nonaka & Takeuchi (1995).

Visualizing knowledge

The complementary process of transforming inside knowledge into information, which we put into the outside world in the form of *information products*: a combination of content and container *designed* to give others access to our knowledge for their own purposes.[2] (Definition based on Orna, 2005, pp. 12-13)
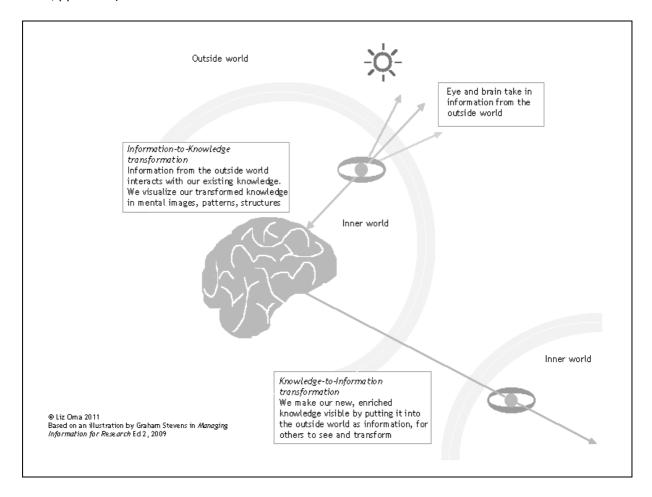

Figure 1. Visualizing and transforming: information from the outside world into knowledge within the mind, and knowledge within the mind into information in the outside world so that others can see and use it. (Based with permission on a figure by Graham Stevens in Orna & Stevens (2009) *Managing Information for Research.*)

Information design

Everything we do to make visible our knowledge and ideas so that those who need them can enter into them and use what they learn from them for their own purposes So information design includes: conceptual structure, sequence, choice of medium and format, decisions about ways in which

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2   The name of 'transformer' was given by Otto Neurath, founder of Isotype, to the specialists responsible for the two processes of visualizing described above. Marie Neurath described her role as transformer in these words: 'It is the responsibility of the "transformer" to understand the data, to get all necessary information from the expert, to decide what is worth transmitting to the public, how to make it understandable, how to link it with general knowledge or with information already given in other charts … the transformer is the trustee of the public…' (Neurath & Kinross, 2010, p. 78)

content is presented, management of the relevant technologies, writing, graphic design, illustration, and typography. (Definition based on Orna & Stevens,2009, p. 15)

Why this topic for this occasion
The search for knowledge visualization has led into domains rather distant from the usual territory of today's information professions, and to some now-forgotten ideas that have been rescued from oblivion by literary scholars. Their origins lie in the monasteries where, from the fifth century AD to the early Middle Ages, revered texts — both Biblical and classical — were copied, and in the Europe of the early Renaissance, during the first hundred years or so following the invention of printing from moveable type in 1453.

The forgotten ideas concerned visualizing and classifying knowledge in order to generate new knowledge, and what Carruthers (1998) calls the 'craft of thought', which applied memory in the process. The groups who applied them could hardly have differed more: in technology — writing vs printing; in purpose — sacred vs secular; and in language — Latin vs the vernacular. But the texts they created show that the same processes were at work in both, and they reveal the importance attached to visual imagery, and to the design of the end products.

Classifying to survive
All living creatures, even single-celled organisms (Damasio, 2010), owe their survival to having some level of what McArthur (1986) has called 'the taxonomic urge' (p. 32). Humans have developed it to an exceptional degree, along with some unique assets:
- Spoken language
- Making their knowledge visible to themselves and others
- Making metaphors and telling stories.

For upwards of 60,000 years, we have applied this combination to the complex task of mastering information from the outside world, transforming it to incorporate it into an inner knowledge structure within which we can move freely, building links within it, to create new knowledge, and finally making it visible to others in the outside world so that they may follow the same processes. We are still doing it today.

Critical stages
The interaction between humans and the tools and technologies they developed for organizing and communicating knowledge has four critical stages, shown in Table 1. Different stages have co-existed over time.

Technology	Start dates	Characteristics
1 Language but no writing	ca. 60K years ago	Knowledge preserved and communicated by sensory means: graphic, song, dance, ritual. Total dependence on human memory
2 Writing	ca. 5000 — 6000 years ago	Writing on various media with various tools. Reproduction by manual copying, so each piece of writing unique. High human memory demands

3		
Printing with moveable type	In Europe, 1453	Exact reproduction, lower human memory demands

4		
Computers	Babbage paper on Analytical Engine 1857; Turing ENIAC 1942; Personal computers mid-1970s	High potential for supporting human memory and thinking

Table 1. Humans and their tools and technologies. Four critical stages

Mental images for thinking and composing in the cloister

Carruthers (1998) has described the purpose of the craft taught and practised by the monks as: 'to "see" their thoughts in their minds as organized schemata of images or "pictures" and then to use these for further thinking' (p. 3). The craft used memory in different ways in two separate aspects of visualizing:

'Inventory'
Carruthers (1998, p. 11) defines this process as: 'the storage of many diverse materials … counted and placed in locations within an overall structure which allows any item to be retrieved easily and at once.' This involved classification and coding to help memorizing. Noah's Ark is the subject of a taxing exercise set for novices by Hugh of St Victor (quoted in Carruthers and Ziolkowski, 2004, pp. 45—70), which entails mentally visualizing the building of a full-colour scale model, and learning its moral and allegorical meaning. we must hope the experience fortified them rather than sapping the will to live. Another treatise by the same writer recommends classifying in the memory 'by number, location, and occasion'. For example, to memorize the Psalms in their sequence: 'I … place them all by order in my heart along my [mental] numerical line and one by one I designate them to the seats where they are disposed in the grid …' (Carruthers and Ziolkowski, 2004, pp. 36—37)

Figure2. Hugh of St Victor's mental construction exercise. © British Library Board. Add.47682.f.7v
Holkham Bible Picture book (011942)

'Invention'
The second application of visualizing was in the creation of new ideas; this uses advanced image-making for 're-collecting' the memories, 'as if [they] have been stored in variety of places and must be called together in a common place … where we can "see" them again and know them in the present.' (Carruthers & Ziolkowski, 2004, p. 1). There was general agreement that the visual sense was 'the most secure for the memory work of composition' for which re-collection of images was the preparation (Carruthers & Ziolkowski, 2004, p. 11).

In the cloister, this step in the final transformation that leads to putting new knowledge into the outside world took the form of preaching, or of writing that disposed visual imagery and classified structures carefully on the page.

The two aspects of visualizing are brought together by the emotional 'colour' that is part of every memory image.

Mental journeys and dynamic diagrams
Metaphors of journeys are used to describe the process of composing. 'Every composition, visual or aural, needs to be experienced as a journey, in and through whose paths one must continually move.' (Carruthers, 1998, pp. 80—81).

Figure 3. Journeys in the mind; Matthew Paris's map of the pilgrim route to the Holy Land: for meditation within the cloister. © British Library Board. Royal 14 C VII,ff,4v-5 Matthew Paris, Historia Anglorum (008497)

Buildings, too, figure in internal pictures; they act as 'a reminder, a cue, a machine for thought' *(*Carruthers, 1998, p. 226). This requires moving in imagination 'through and within its structure, as though within a material building', something difficult to conceive of today, because 'We are now so accustomed to think of diagrams as the static and abstract forms of already-rationalized subject matter.' (Carruthers, 1998, p. 251).
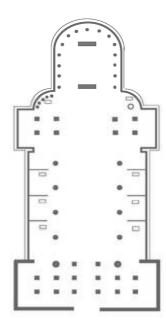
Figure 4. The monastic building plan as a meditation machine: Bishop Haito's 9th century plan of an ideal Benedictine monastery for St Gall; redrawn for the English edition of Wolfgang Braunfels' *Monasteries of Western Europe*, Thames & Hudson (1972). Reproduced by permission of the publisher. Image supplied by British Library © British Library Board.

Mind and brain; looking inward

Those who practised this mental craft also sought to relate what was going on in the mind to the structure of the brain. A diagram of its functions, from a 13th century MS, reproduced in Carruthers & Ziolkowski (2004, p. 122), shows the influence of the Arabic scholars, Avicenna and Averroes.
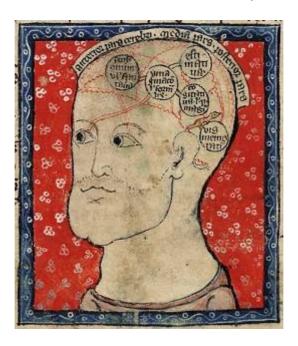

Figure 5. Medieval diagram of human brain function.
Cambridge University Library MS Gg 1.1. fol.490 DV. Reproduced by permission of the Library.

The enduring end product — designed pages

The end products we have inherited are manuscripts whose every element was *designed* for the purpose. As Carruthers (1998, p. 122) writes, 'the pages as a whole, the complete parchment with its lettering and all its decoration, was considered a cognitively valuable "picture".'

The tendency throughout the Middle Ages was 'to see words in the first instance as single letters variously combined in syllables, rather than to "comprehend" them at once as semantic units. … Words are thus understood to be *constructions made up* out of syllables, not simplexes of meaning. … Meaningful signs result from a "play" of non-semantic units, in a way akin to graphic design … ' (Carruthers (1998, pp. 136—7), and knowledge tends to be viewed as 'involving recombinant sets of design elements, whose units are sub-semantic "signs" of all sorts that *make* meanings … in constantly varying combinations with other "signs" ' (p. 137). So it was that what we would now call information design became integral to the business of organizing and communicating knowledge in the Middle Ages.
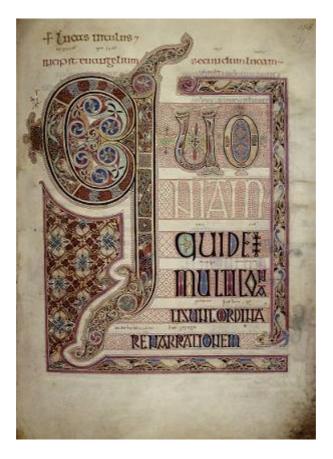

Figure 6. The end product of monastic composition: pages that are a 'cognitively valuable picture'. The opening of St Luke's Gospel from the Lindisfarne Gospel. © British Library Board. Cotton Nero C.IV, f.139 Lindisfarne Gospels (060782).

The age of the printing press

The memory crafts of the cloister — in the words of Bolzoni (1995, p. xix), 'a mode of perceiving words and images, a mode of receiving (and creating them) … that has been discarded and forgotten because of its differences from our own.' — continued to flourish during the first hundred and fifty years after the introduction of Gutenberg's printing press. Social context and purposes were

different, but visual imagery, the ordering of ideas, and their visible embodiment in carefully designed end products characterized the new medium as they had the old.

Ambitious plans in Venice
The Accademia Veneziana, founded in 1557, offered a high-minded combination of public lectures, publishing programme, and library. Its press was directed by the humanist Paolo Manuzio, a son of the Aldo Manuzio, who maintained the family's high standards of paper, typefaces and printing in the Academy's publications. He also venerated the love of classification as 'the fruit of the imprint left by God on man and the order of the universe.' (Bolzoni, 1995, p. 11). The Academy planned to apply an encyclopaedic classification not only to the works it published, but also to its library, the departments that administered its work, and even the layout of its building. Within a few years, however, it succumbed to lack of funds, leaving most of the plans unrealized. But the use of visual imagery and classification persisted in other contexts.

'Words become things' — the alchemy of the printing press
The advent of the printing press actually deepened and intensified the 'design' features of monastic MSS, because it gave letters a solid physical reality. Arranging words on the page made them 'become things, transforming them into an artificial product that will endure through time.' (Bolzoni,1995, p. 238). A vision-story (Nazari, 1559, cited in Bolzoni, 1995, pp. 104-109) of a journey through three kingdoms of alchemy symbolizes the near-mystical power of printing. The story of the second kingdom is a celebration of Gutenberg and the invention of moveable type. Bolzoni (1995, pp. 108-109) comments:

> 'The printing press had made knowledge visible: the letter — in its dimension as a symbol, but also in its material consistency … is impregnated by human experience and transmits it to future generations, giving shape, memory and visualization to the chaos of history.'

Wayfinding in the forest of words
Classification had practical advantages as well as celestial sanction. Combined with attention to visual design, it was seen, and used, in the mid-1500s as:

> 'a method that will rigorously regulate both knowledge and the ways of communicating and recalling it: the diagrams, the tables, and the large schemes in the form of trees visualize a logical path to be taken, and hence all of the material is presented to the eye re-ordered and re-organized in a clear and effective fashion that is easy to remember.' (Bolzoni, 1995, p. xix)

In 1549 Francesco Robortello gained advantage over academic rivals and popularity among his students by publishing an elegant tree diagram, displaying the classified structure of his course in rhetoric (Bolzoni, 1995); while Citolini (1561), quoted by Bolzoni (op. cit.) offered readers a 'grid' based on a hierarchical tree classification to use in organizing their own collection of favourite quotations.

Visual jokes, calligraphy, Utopian games
These matters were not always treated solemnly. A woodcut of the 'House of grammar', attributed to Vogtherr and reproduced in Bolzoni (1995) puts a classified structure of Latin grammar into a picture full of visual jokes and mechanical devices that bring to mind Rowland Emmett's drawings. Agostino Ramelli's 'rhetorical machine' for the mechanical composition of texts, reproduced in Bolzoni (1995, p. 64) anticipates Sir Walter Scott's notion of a steam-powered engine for 'Writing the Class of Works Called the Waverley Novels' (Scott, 1852).

Figure 7. Latin grammar embellished with visual jokes. Vogtherr's Tower of Grammar (1548). Author's photograph of poster published in the US by Poster Revolution; image considered by the publisher to be in the public domain.

Members of the Roman 'Academy of Disdain' combined 'a taste for practical jokes and extravagance, and a lively carnival spirit' (Bolzoni, 1995, p. 87) with love of the visual arts and letters, which found typical expression in rebuses – playfully serious combinations of words and images, embodying visual puns that cast new light on the sense. The Academy's secretary, the distinguished calligrapher Palatino (1540), embodied many in his treatise on letterforms and ciphers (1540).

The beauty of such products lay in 'harmonious varied arrangement of different components on the page … the elegance in the arrangement of letters [and] in the play between the visible and the legible.' (Bolzoni, 1995, p. 89).

The early Renaissance fascination with alphabets is exemplified in the invented alphabet of Sir Thomas More's Utopians, who played a game of 'the contest between the virtues and vices' (More, 1518, cited in Bolzoni,1995, p. 88)
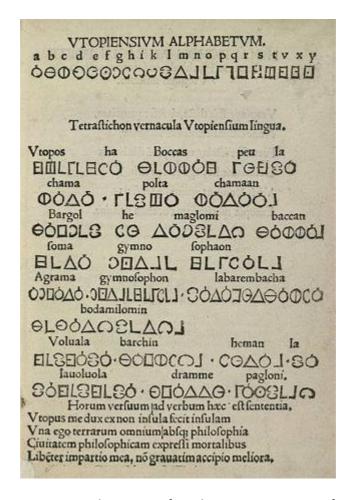
Figure 8. Alphabet of the Utopians. From *The Utopia of Sir Thomas More, in Latin from the edition of March 1518*. Facsimile published Clarendon Press: Oxford, 1895. © British Library Board.12352.dd.9.

Mind, brain and the unconscious

Brain maps similar to those of the 13th century appeared also in the early 16th century. They reflected a continued search for answers to such questions as:

- How does the mind within interact with the material world outside?
- What happens in the intermediate zone between them?
- What part does the brain play in the interaction?

The drama of the unconscious mind in the 'theatre of memory' was also imagined: Ciampoli (1649) wrote of the 'commotion … inside our heads' created by the 'unguarded phantoms' of our images when we sleep: 'They sing, they sigh, they dance, they war … recklessly unregulated, furiously, surpassing the works of nature with the inventions of dreams. ' (quoted in Bolzoni, 1995, pp. 258-9).

An end and a beginning

The knowledge crafts described here ended in the 17th century; they fell victim to the very expansion of knowledge that came from their exercise. The long-lived vision of a single scheme encompassing all knowledge reached its end as arts and sciences blossomed into separate disciplines. But visualizing and classifying knowledge continued, flowing in new directions, in many different streams. For example:

- The Increasingly sophisticated techniques of cartography embodied in the magnificent maps of the 17th century (Barber 2010).
- William Smith's revelation of a hitherto invisible underground landscape in his 1815 geological map (Winchester, 2002).
- Taxonomy development in the biological sciences from the 18th century onwards (Gould, 2002).
- The mental visualizations and diagrams used by such scientists as James Clerk Maxwell and Richard Feynman as an intermediate creative stage in developing new theories (Mahon, 2002; Glieck,1992).
- Visual interplay between art and science of the kind described by Kemp (2000).
- The transformation of statistical information into visible knowledge for communication, from Playfair in the 18th century, through 19th century Austria, to Isotype in the 20th century (Tufte, 1983; Neurath and Kinross, 2009).
- The great library classifications of the 19th and 20th century (Mills, 1967; Vickery, 1960 and 1973).
- Contemporary developments in neuroscience that acknowledge the role of the emotions, and of classification (Damasio, 2010; Rose, 2006).

The flourishing of separate arts and sciences brought losses as well as gains; it became harder for them to talk to one another, and moving across increasingly entrenched boundaries could even be seen as a suspect, unscholarly activity.

Lessons from a distant past?

Having invited readers on this excursion, it is now my obligation to suggest what we might learn and how we might apply it in dealing with today's problems. I shall try to do it in the light of experience from working life. The most important insights are, to my mind:

- The value attached to vision, of eye and mind, in the internal organization of knowledge, and in putting it — in the form of the carefully designed pages of manuscripts and printed books — into the outside world for use.
- The significance assigned to the senses and feelings, and the associated ideas about the role of brain and mind.
- The creative interplay between the people who have left us the products of their knowledge, and the technologies they used to serve them in organizing and communicating it.

They are important because, if we want to apply the forgotten methods of past centuries to today's problems of visualizing and classifying knowledge, these are the critical features that have permanent value (as suggested in Table 1, memory techniques were invaluable in the then-available technologies, but became progressively less important with each stage of development.) Their implications are explored below.

I can offer two things learned from experience that may be useful for applying those insights. The first comes from over 30 years of working with information designers. My task was described as teaching students of graphic and industrial design about organizing information from their research, and writing their dissertation. In fact it became the most fruitful mutual learning experience of my career. I found that their typical holistic visual approach, often seen as a disability, actually allowed them to visualize mental structures, and to put them into the outside world by displaying them simultaneously in the same plane, rather than wrestling with turning ideas in the head into strings of words. In fact it was an asset that could be deliberately used in designing an end product that

combined visual and verbal elements to good effect. Ideas and methods learned from the process are embodied in the book written in collaboration with its designer Graham Stevens, in the hope of encouraging other researchers to adopt a 'design approach' (Orna & Stevens, 2009).

The second kind of experience has come from consultancy assignments, from my own research, and from writing books that present actual examples of something very close to the long-forgotten practices of the Middle Ages and the Renaissance. It has two aspects. One is a process of *individual reflection*, allowing time to let thoughts develop, to take journeys in the mind, and to explore emerging structures and patterns. Seeing thoughts in the mind, as what Carruthers (1998 p. 3) calls 'organized schemata of images', in order to make sense of data and information they have gathered from the outside world, is part of the experience of some of the recent researchers who contributed to *Managing information for Research (*Orna & Stevens, 2009). My own preparation for writing has developed in this direction over the years, influenced by my co-author's use of a visual framework, derived from his experience of designing the writing of others, as a preliminary to his own writing (op. cit. pp. 239—248).

The other relates to the complementary process of 'making knowledge visible' by transforming it into information, so as to put it into the outside world and communicate it to others in the form of 'information products'. It is described in many of the accounts from organizations related in Orna (2005); the information products range from museum websites and in-gallery displays, to catalogues of electronic products, and a website with associated printed products for school governors. In that particular case (described in Orna & Jennings, 2010) the end users were active participants in proposing and developing the end products.

This transformation of knowledge parallels the stage of 'invention' described by Carruthers as 'advanced image making' — the process of putting new knowledge into the outside world in a form that displays imagery and organized structures on designed pages. It is significant that these activities entailed *co-operation among groups* of people from different information-related professional backgrounds, including information designers, who came together willingly, often on their own initiative, to meet an organization's need for specific knowledge by transforming it into appropriate information products designed to communicate the knowledge to those who needed to make it their own and use it.

I draw these conclusions from the experiences described:
- Information design as defined in this paper has an essential role to play in organizing and communicating knowledge for use.
- Co-operative endeavour — like that of the Academies of the Italian Renaissance, which included not only serious exchanges but also elements of creative play — by virtue of addressing a real task, may do more to promote interdisciplinary co-operation than meetings of representatives of the different disciplines convened to discuss how to overcome their fragmentation.

Final thoughts

I leave you with two final thoughts for consideration. The first relates to the hazards that accompanied the advance of separate disciplines, and it brings to mind an image of groups of people standing on the same territory, but living in parallel worlds so that they are unaware of others sharing the space with them. If we are so corralled by the norms of our working environment or our professional discipline that we lose the habit of 'looking outside the traditional and well-worn comfort of a particular discipline, and making new connections' (Graham Stevens, personal

communication, 3 April 2011), we cut ourselves off from the chance of finding new ways of looking at the world and creating new ideas.

The other is about the creative interplay between people and the technologies they create; and how they use them in organizing and communicating knowledge. They managed that pretty well in the period we've been looking at, and if we put our minds to it, so could we today. Humans can actually enjoy thinking hard and generating ideas, and having conversations about them — they're good at it and it does them good. Brian Vickery throughout his life set us an example of conversing across boundaries, and seeking a division of labour between humans and the 'knowledge technologies' they have created that will allow us to retain that enjoyment and the benefits it brings.

Acknowledgments

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