# The language of graphics

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# Abstract

In this thesis we propose a framework for the analysis of graphic representations of information. Graphic representations seem to play an increasingly important role in our lives. While our common sources of information (e.g. books, newspapers) used to be almost completely textual, we are now seeing more and more diagrams, pictograms, maps and charts. We see such graphic representations on paper as well as on signage and on screen. Some types of graphic representations have developed due to recent advances in computer technology, while others can already be found on archeological objects from ancient cultures. In this thesis, 'graphic representations' are taken to include prehistoric maps and Egyptian hieroglyphs as well as family tree diagrams, pictorial statistical charts, and modern 3-D computer visualizations. In the context of this investigation we will limit ourselves to static representations.

Graphic representations can be regarded as expressions of visual languages. The primary aim of the thesis is to examine the main principles of these visual languages, regarding both their graphic syntax and their interpretation.

In Chapter 1 we lay out the context of this work, discussing the notions of *graphic representation* and of *visual language*, and we elaborate on the aims of this thesis.

In Chapter 2 we examine the *syntax* ('grammar') of graphic representations. Section 2.1 provides an overview of our approach to graphic syntax and its recursive nature. A graphic representation may be elementary or composite. We regard a composite graphic representation as consisting of a *graphic space*, a set of *graphic objects* and a set of *graphic relations* that these graphic objects are involved in. A graphic object may itself be a composite graphic representation, so this approach can be applied recursively. Graphic relations may concern either *spatial structure* or variations of *visual attributes*. On a subway map for example, the colored lines, the station markers, and their textual labels are all *graphic objects*. Some of the *graphic relations* between the colored lines involve variations of a *visual attribute*, in this case color. Some of the *graphic relations* between station markers involve *spatial structure*, in this case their spatial positioning, and their connectedness by the colored lines. In section 2.2 we briefly explore *graphic space*, which is the substrate of all spatial relations within graphic representations. In sections 2.3 and 2.4 we take a brief look at *elementary graphic objects* and their *visual attributes*.

By far the longest section is section 2.5, in which we explore the various types of basic and composite *syntactic structures* into which graphic objects can be arranged within a graphic space. We regard the syntactic structure of a graphic representation as a set of graphic relations. These graphic relations

may be object-to-*object* relations or object-to-*space* relations. An object-to-*object* relation is a relation between objects (subsection 2.5.1), while an object-to-*space* relation is a relation between an object and one or more points in a *meaningful space* (subsection 2.5.2). For example, the labeling of a city on a map of a country involves an object-to-*object* relation between two objects: the name of the city (a textual label), and the 'city-dot' that marks the city's location. The name of the city will usually be placed close to the 'city-dot', either above or below it, or to its left or right. The spatial positioning of the 'city-dot' itself however, involves an object-to-*space* relation between the 'city-dot' and a specific point in the meaningful space of the map. Similarly, a line that connects two boxes in a flow chart involves object-to-*object* relations between the line and the two boxes, while a curve in a two-axis chart involves object-to-*space* relations between the curve and a set of specific points in the meaningful space of the chart.

Closely related to the above is the notion of *syntactic roles*. Somewhat comparable to the different syntactic roles that words can play within the syntactic structure of a sentence (e.g. the role of noun phrase or verb phrase), graphic objects can play different syntactic roles within the syntactic structure of a graphic representation. We examine these different syntactic roles (subsection 2.5.3), and discuss how they differ with regard to the spatial 'anchoring' that they involve. A 'city-dot' on a map for example functions as a *point locator* (anchored to a point in a meaningful space), a word underneath a bar in a bar chart functions as a *label* (anchored to the object that it labels), and an arrow in a flow chart functions as a *connector* (anchored between the objects that it connects). Other possible syntactic roles of graphic objects include *separators* (e.g. dividing lines), *containers* (e.g. a framing box), *line locators* (e.g. a curve in a two-axis chart), *surface locators* (e.g. a lake on a map), and *metric bars* (e.g. the bars in a bar chart).

We round up section 2.5 with a discussion of different types of *composite* syntactic structures (subsection 2.5.4). We examine the *graphic multiple* for example, which consists of two or more variations of a graphic representation. Other types of composite syntactic structure include the *multipanel* with a *shared axis*, and the *background-inset display*.

In Chapter 3 we deal with various aspects of the *interpretation* of graphic representations. First we discuss *type of correspondence* (section 3.1), which we define as the relationship between what is *shown* and what is *meant*. The main types of correspondence that we distinguish are *literal, metaphoric, metonymic, rebus-based,* and *arbitrary-conventional*. For example, a pictogram that indicates a restaurant by showing a knife and fork, is a *metonymic* graphic object, while the relative spatial positioning of graphic objects along a time line involves a *metaphoric* use of graphic space. After type of correspondence we discuss *mode of expression* (section 3.2), which concerns the classification of graphic objects into *pictorial* objects (in a spectrum from realistic to schematic pictures) and *non-pictorial* objects (abstract shapes, words and numbers). Sorting out a confusing issue in the literature, we discuss the non-trivial relationship between *type of correspondence* and *mode of expression*. We then discuss the *informational roles* (section 3.3) that graphic objects may play within a graphic representation, distinguishing between *reference objects* (e.g. legends, labeled axes, grid lines), the actual *information objects* (which would have to be adjusted if the represented information would change, e.g. a curve plotted in a two-axis chart), and *decoration* objects. We conclude Chapter 3 with some very brief remarks on the *types of represented information* that may be involved in graphic representations (section 3.4).

In Chapter 4 we offer a *classification* system of graphic representations, giving principled descriptions of the proposed types of graphic representations, and discussing existing classification systems.

In Chapter 5 we examine how the framework developed in this thesis can be applied to the analysis and discussion of real-world graphic representations, as well as to the analysis of graphic theories from the existing literature. Concerning the application to real-world graphic representations, we briefly discuss the standardized analyses in the captions of the numerous example figures throughout the thesis. Concerning the literature, we show for a large number of existing graphic theories how they can be 'translated' into the terms of this framework.

Finally, in the Conclusions (Chapter 6), we make an attempt to assess the value and the possible applications of this work.