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Paradigms in Cartography.  
An Epistemological Review  
of the 20th and 21st  
Centuries

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# Introduction

The first mention of cartography as a *science* occurring in an internationally binding official document occurs in a report issued by the United Nations Department of Social Affairs in 1949 (United Nations 1949) entitled “Modern Cartography. Base Maps for World Needs”. In their Introduction the involved experts state that:

Modern cartography covers a wide and complex range of subjects. Maps may portray political boundaries or oceanic depth, the geological structure of the earth’s surface or the density and distribution of its population; they may be used to represent, in graphic form, inventories of the world’s natural and industrial resources or of educational facilities. Military requirements, it is true, still retain a high priority in map making. However, it is equally true that the services provided by cartography are being increasingly utilized for peaceful purposes. This fact is perhaps the dominant feature of the development of cartography during the last hundred years. The progress of the *Science of Cartography* [italics not in original document] is of equal concern to all nations.... (United Nations 1949: Introduction).

Nevertheless, cartography has commonly been considered to be both *science* and *technique*, as well as an *art* in the design, construction and study of maps. An analysis of cartography in *philosophical* and *epistemological* terms, however, raises important aspects. A *positivist* perspective of sciences, for instance, denies art as a part of cartography. On the other hand, from a *humanist* point of view the subjective aspect of maps is emphasised, and at the same time the scientific view on the discipline is criticised. If one focuses only on the *technological* aspect of cartography, emphases are put on a *pragmatic* vision of the “reality”, leaving aside all other aspects of map analysis. In turn, if maps are examined from *historical* and *hermeneutic* points of view, then they are considered *texts* which convey a *political–cultural–social context*, in which power relation and subjectivity acquire relevance. Therefore, in this book, besides highlighting epistemological and philosophical issues, cartography is considered a solid body of knowledge to understand our world with all its different facets. The authors try to follow an *analytical and holistic view* of the more recent historical developments

in cartography. This is also corroborated by not only treating map theory but also map-use aspects and can thus demonstrate the *theoretical eclecticism* in cartography.

In 1982, in a precursor to his famous book about the theory of cartography, published 5 years later, Rudi Ogrissek (4.9.1926–27.9.1999) preempts several of his later thoughts and displays, in particular, some seminal illustrations (Ogrissek 1982). This 80-page booklet, which is to a great deal based on findings of Eastern, especially Russian, cartographers, and which was primarily meant as a textbook for East German students, is remarkable for various reasons: Among others, Ogrissek therein coined the excellent term '*imagination map*' ('*Vorstellungskarte*'), thus drawing on models by A. M. Berljant, K. A. Salishchev and A. S. Vasmut (Ogrissek (1982) and thus being in a sort of contrast to the early papers by Gould and White (1974) and Kishimoto (1975) who use the nowadays widely accepted term "mental map". Anyway, this work represents one of the first more comprehensive publications on the theory of cartography outside the region of Slavic languages and brought, for the first time, ideas of the former Soviet cartographers into a non-Russian language.

Already in 1986, Joel Morrison, co-author of the renowned textbook on cartography (Robinson, Sale and Morrison 1978) and president of the International Cartographic Association (ICA) from 1984 to 1987 (Wolodtschenko 2008) criticised the missing philosophical research in cartography (Morrison 1986). Consequently, this led to the establishment of an initial working group and later a Commission on Theoretical Cartography within ICA. At the 16th International Cartographic Conference 1993 in Cologne, Germany, a first report of this international working group was presented, the results of which have later been published (cf. Kanakubo et al. 1993). This paper nicely shows how scientific paradigms work (hint by courtesy of Zsolt Török, Budapest, written communication 2012).

The present book incorporates Thomas Kuhn's *Concept of Paradigm*. It deals with the different thoughts and tendencies which contemporary cartography has experienced during the so-called modern and postmodern periods. Thus, current trends in cartography are analysed regarding the extent to which they can be identified as paradigm shifts. For each cartographic trend it is necessary to keep in mind the theoretical schemes of a scientific discipline (study object, research aim, method and results) which are supposed to determine its body of knowledge. The above will reveal if cartography has been having its own paradigms, which would imply it has its own autonomy, or if its body of knowledge comes from other sciences. Finally, the theoretical character of the study should help us to understand the discipline beyond its practical-technological aspects. It represents a theoretical contribution, because the analysis of the cartographic tendencies stresses, from an epistemological viewpoint, their scientific, deconstructivist and ontological levels.

Regarding the need for theory, this book is not only supposed to be a contribution to theoretical cartography but also to represent a sort of stimulating contribution to the development Modern cartography covers a wide and complex range of subjects. Maps may portray political boundaries or oceanic depth, the geological structure of the earth's surface or the density and distribution of its population; they

may be used to represent, in graphic form, inventories of the world's natural and industrial resources or of educational facilities. Military requirements, it is true, still retain a high priority in map making. However, it is equally true that the services provided by cartography are being increasingly utilized for peaceful purposes. This fact is perhaps the dominant feature of the development of cartography during the last hundred years. The progress of the *Science of Cartography* [italics not in original document] is of equal concern to all nations.... (United Nations 1949: Introduction) of cartography in the twenty-first century. We feel that currently a growing awareness for the need of a theoretical basis of our passion, cartography, is arising among both academics and professional cartographers. It seems that today this need is no longer questioned.

Whenever possible, the authors based their statements on the primary literature. In some rare cases, however, this was not feasible. We are, albeit, well aware that the secondary literature sometimes might include disputable and/or superficial statements.

The book is divided into nine chapters and a Reference section. **Chapters 1 and 2** analyse the theoretical bases. The link among philosophy—emphasizing the relationship between object, subject and image—epistemology and cartography is analysed. In **Chap. 1**, in the traditional way of knowledge theory, first the different so-called “isms” are examined in their relationship between subject and object. Second, three epistemological-philosophical perspectives are analysed: *positivism-empiricism*, *neopositivism* (logical positivism) and *postmodernism* (poststructuralism). Within every period the impact on cartography and mapping is described. Then, the consolidation of geography as a scientific discipline and its effect on cartography during the positivist period is considered. Cartography as a science or discipline has then been taking the scientific features corresponding to the positivist context.

In **Chap. 2** three great philosophers are treated. First, the traditional legacy of Immanuel Kant and then two contemporary philosophers of the logical positivism: Ludwig Wittgenstein and Karl Popper. Emphases are put on the question of how cartography grasps epistemological aspects in knowledge construction. Although the two aforementioned authors did not directly write about cartography and mapping, their legacy has had an important impact on our understanding of maps. The evolution of contemporary cartography can be linked to the development of Wittgenstein's thinking (Wittgenstein's *First and Second Philosophy*). On the other hand, the cartographic products and the different stages of map creation can be linked to Popper's Three Worlds Theory. The statements of these two philosophers are related under stances of scientists who rather belong to the cartographic field such as Herbert (2002), Lois (2000, 2009) and Cauvin et al. (2010). During post-modernism new tendencies and perspectives arose from *social theory*. Their relationships with cartography and mapping are also discussed. Also, this part of the book refers to the contribution of Immanuel Kant, especially his links with

geography, and the concepts of space and time. The aim of this comprehensive [Chap. 2](#) is to lay the theoretical bases of or rather for cartography, as this should help to understand the discipline beyond its technological issues.

For the remaining part of this book the major theoretical fundamentals are made up of the paradigm concept developed by Thomas Kuhn in the context of the history and philosophy of science (Kuhn 1962, 1970). This topic is treated in [Chap. 3](#). The term *paradigm* has several interpretations, but in general includes a scientific community (in a particular field of knowledge) in which common aims and criteria during a determined period of time are shared. These periods are also called *normal science*. The replacement of a paradigm by another one is known as *scientific revolution* or *crisis period*. Therefore, our views incorporate Kuhn's epistemological concept of paradigm in order to be later applied to the discipline. Thomas Kuhn's ideas are taken as given and valid, they allow to analyse the extent to which contemporary tendencies in cartography can be identified as paradigmatic elements within the scientific community.

[Chapters 4–6](#) focus on a review of the state of the art and recent trends in cartography. [Chapter 4](#) deals with several authors and theoreticians who analysed the discipline during its contemporary development under certain paradigms and currents (Peterson 2002; Perkins 2003; Wood 2003; Ramirez 2004; Edney 2007; Ormeling 2007; Sui and Holt 2008; Cauvin et al. 2010). It also discusses geovisualisation (DiBiase 1990; DiBiase et al. 1992; MacEachren 1994, 1995; MacEachren and Kraak 2001), analytical cartography (Moellering 2000, 2001; Tobler 1976, 1979) and cyber-cartography (Taylor 2005, 2009) approaches.

Beginning in the second half of the twentieth century, various authors, from Robinson (1952) up to MacEachren (1995) and Taylor (2005), established and ascertained scientific trends. Tendencies such as cartographic language, cartographic communication model, analytical cartography, geovisualisation and cyber-cartography are framed into a neopositivist approach of modernity. Therefore, in epistemological terms, cartography and mapping try to reach a representation (depiction) of the geographical space as veridically as possible: accurate, precise, secure and objective. This is considered the main aim of cartography: to reach an objective representation of the world. In other words, in this case, the metaphor of the map as *reflection* or *mirror* of “reality” is valid.

Although in [Chap. 4](#) *critical cartography* is described as a new tendency, beginning in the 1980s, [Chap. 5](#) still deepens its treatment in the postmodernist context. The critical perspective is a historicist view of cartography that poses a conception of the map as a text or vehicle of *power and knowledge* (Harley 1988a, b, 1989, 2001). Thus, there exists a historical critique of the power of maps in different times and places, and a contemporary critique of maps regarding ethical considerations and values (Crampton and Krygier 2006; Wood and Krygier 2009; Crampton 2010). The chapter examines John B. Harley's legacy and his link with postmodernist thinkers such as Michel Foucault and Jacques Derrida. In this way, the critical approach points out that maps act as *rhetorical* devices which implicitly and

explicitly pass messages of hegemony and power in a specific social-political context. In this context, the map acts as a subjective device, biased, loaded with values and meanings. Thus, in agreement with the so-called postmodern authors, it is stated that the critical perspective constitutes a *paradigmatic shift* that breaks with the objectivity and neutrality claimed by the previous stances.

Continuing in the postmodern cartographic context, [Chap. 6](#) focuses on new map conceptions which are challenging the previous ones (Latour 1987, 1999; Crampton 2003; Pickles 2004; Casti 2005; Wood and Fels 2008; Della Dora 2009). Additionally, since the end of the 2000s, some authors such as Rob Kitchin, Chris Perkins and Martin Dodge have taken up a *postre presentational* attitude in which cartography and maps are seen to be beyond the previously established formal and positivist aspects. Consequently, the traditional *ontological* conception of maps is criticised and replaced by an *ontogenesis* conception (Kitchin and Dodge 2007; Kitchin 2008; Kitchin et al. 2009). This conception proposes that a map is not an epistemologically *stable and secure* product (as taken for granted in the scientific and critical approach), but rather the result of the moment: it is subject to continuous *re-creation* and *re-interpretation* according to the context in which it is situated. The map is seen *to be in action*. It is in a *state of becoming*. In this book this new perspective is discussed as a possible, ongoing *emergent paradigm* in Kuhnian terms, subject to considerations regarding the epistemological and ontological bases of the discipline.

In [Chaps. 7 and 8](#) a methodological proposal to identify paradigms in cartography is set forth. [Chapter 7](#) analyses whether at all there exists a possibility for paradigms in cartography as defined by Kuhnian terminology. Here, in methodological terms, two approaches are proposed. The first one is called “*criteria of contrast*” (e.g. study object, research aims, method and approach, results, etc.). These criteria are applied to identify formal and factual sciences and also to differentiate between regional and quantitative geography. The second methodological procedure is named “*tendency distribution in the epistemological space*”. In this context, contemporary cartographic tendencies are located under the three philosophical-epistemological bases of modernity and postmodernity: positivism-empiricism, realism-structuralism, idealism-hermeneutics. As shown in [Chaps. 4–6](#) (Part II) several cartographic trends have occurred since the second half of the twentieth century. Will, in epistemological terms, these tendencies shape groups or clusters or will they remain isolated? If they were disparate trends, would we be able to propose some internal paradigm shifts within cartography? The two applied methodological criteria allow the identification of some internal *worldviews*—as termed by Kuhn—during the contemporary development of the discipline.

[Chapter 8](#) discusses the results obtained in [Chap. 7](#). At first, seven paradigm tendencies in cartography are proposed, based on the criteria of contrast and the opinions published by the authors that have been critically reviewed in the previous sections. On the one hand, the body of knowledge of the discipline is characterised through the distinction between the scientific and critical approaches (i.e. by contrasting paradigms), and on the other hand by the transition between both stances. Also, post-representational cartography is considered a paradigmatic proposal



**Fig. 1** What this book is all about in Cartography. Figure adapted from <http://www.helenleeauthors.com/2011/09/understanding-your-vocation-life/>; <http://streamlinetosucceed.com/wp-context/blogs.dir/50/files/2011/03/who-what-where-280.png>

which challenges previous approaches. Here, the ontologically secure map is doubted. In Kuhnian terms this development deserves to be observed in an alert manner regarding a new worldview in cartography and mapping.

The second part of **Chap. 8** returns to Kuhn. His scientific revolution theory is discussed within the scope of intrinsic paradigms in cartography. In epistemological terms, three levels are examined: scientific, sociological and ontological.

As a result of the last chapter the authors state that, if the development of cartography and mapping is considered to take into account the epistemological

coordinates, then three paradigm shifts in Kuhnian terms can be postulated: scientific-empirical, critical and post-representational. Despite the fact that these three paradigmatic shifts have been triggered by technological development, the theoretical statements made in this volume go beyond technological issues in cartography and mapping. This theoretical posit is corroborated by philosophical and epistemological considerations about the development of the cartographic science. Finally, a chapter with conclusions and a comprehensive list with literature references are presented (Fig. 1).

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# Chapter 7

## Possibilities of Paradigms in Cartography

### 7.1 Introduction

Basically, there are two ways of analysing whether Kuhnian-type paradigms exist in cartography. First, we apply the *criteria of contrast* used in the distinction of science types. These criteria establish the differences between formal sciences and factual sciences and also distinguish between regional and quantitative geography. Second, an analysis based upon the ‘tendency distribution in the epistemological-space’ (Azócar 2012) is applied. The distribution or ‘location’ of tendencies permits the identification of paradigmatic-shifts according to epistemological and philosophical ‘coordinates’. The term coordinates corresponds to the three bases of modern thought: positivism-empiricism, realism-structuralism, and idealism-hermeneutics. This approach is applied to modern geographic thought and then to the cartography of the modern and post-modern period. The aim is to locate cartographic tendencies according to the epistemological coordinates rather than to describe the technological changes that occurred during the development of the discipline.

### 7.2 Criteria of Contrast

In his comparison between factual and formal sciences, Mario Bunge (1998) identified criteria of contrast<sup>1</sup> which are important to distinguish between these two types of critical sciences. They are, among others: study object, research aims, methods and techniques, results in research or/and practice, purpose or finality. These criteria can be adapted according to different sciences and disciplines. Thus,

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<sup>1</sup> These criteria of contrast are also called ‘contrasting parameters’ (reference). In this book, however, they are named criteria of contrast due to their epistemological and theoretical nature. A criterion of contrast is an indicator that permits the description of distinctions between types of sciences, e.g. formal/factual sciences or physical/social sciences. Some criteria of distinction are the following:

criteria of contrast are used to reach the proposed objectives to verify whether the development tendencies in cartography correspond to the paradigmatic trends experienced in the development of sciences in general.

Some criteria of contrast are the following:

- Study object: main subject (topic) analysed in each discipline or science.
- Research aims: what led to an explanation and prediction of reality through laws and generalisations or only a description of reality through unique and particular cases.
- Research method: covers the general methodology used: hypothetical-deductive or empirical-inductive or both.
- Statement type: refers to the establishment of synthetic propositions, e.g. factual sciences, or analytical ones, e.g. formal sciences.
- Purpose or finality: distinguishes between explanation and prediction of reality, i.e. natural/physical sciences, or only its description, i.e. human/social sciences.

Table 7.1 shows the comparison between factual sciences and formal sciences. A first criterion is the study object. In this case, facts and phenomena of our experience are studied by factual sciences, i.e. physics, chemistry, biology, and entities of ideal character—abstractions—are treated by the formal sciences, i.e. mathematics, logic, geometry. Certain research methods are used by the respective science type and associated with it. Then different statement types are established: On the one hand there is the empirical contrast with synthetic propositions in the factual sciences, on the other hand the logic-deductive demonstrations with analytical propositions or statements in the formal sciences (Bunge 1998).

According to the above methods, the purpose or finality is to reach the desirable knowledge. In this case, the purpose is descriptive, explicative, and predictive for the phenomena belonging to the factual sciences in comparison to purposes about the construction of the abstract thought system of the formal sciences.

Among others, the epistemology of science aims to take into account criteria for the distinction between the types of sciences or disciplines that help to increase our particular knowledge of the physical and abstract world.

**Table 7.1** Criteria of contrast for factual and formal sciences based on the conception of Mario Bunge (adapted from Bunge 1998)

Factual sciences	Criteria of contrast	Formal sciences
Facts and phenomena of the experience	<i>Study object</i>	Entities of ideal character
Empirical contrasting	<i>Research method</i>	Logic-deductive demonstration
Synthetic propositions	<i>Statement type</i>	Analytical propositions
Description, explanation, and prediction of phenomena of the universe	<i>Purpose (finality)</i>	Construction of abstract systems of thought

### 7.3 Contrasting Paradigms in Geography: An Example

Apart from those mentioned above there are other criteria of contrast, according to the peculiarities of each discipline. In geography for instance, there exist: paradigm name, tendency or school of thought, general methods, and cartographic product (as a practical result). These criteria are useful for differentiating internal tendencies in a discipline.

Some criteria of contrast which establish the differences between two traditional tendencies in the field of geography are presented in Table 7.2. As shown in the previous sections, there was a distinct difference in the geographic thought between traditional regional geography and a new trend called quantitative geography during the first half of the twentieth century. The former is underpinned by historicism and the latter by neo-positivism. In Table 7.2 these differences are presented according to the established criteria of contrast. For traditional geography, the study object is the region (or a specific place) and for quantitative geography, the spatial relationship. For more details regarding these tendencies see Harvey (1969), Capel (1983, 1998), Gomez Mendoza et al. (1988), Ortega Valcárcel (2000).

Table 7.2 shows the general method and the more specific methods and techniques, i.e. approaches, used in geographic tendencies. Regional geography commonly applied the empirical-inductive method, and its approaches were classificatory, comparative, and historical. Quantitative geography, however, has been using the hypothetical-deductive method, and its technical approaches were mainly statistics, modelling, and data correlation. These techniques permitted the verification of previously established hypothetical statements.

The research results of regional geography led to typologies and the classification of places and regions in the world. These typologies are considered to be particular

**Table 7.2** Criteria of contrast for two paradigmatic tendencies within the field of geography (after Azócar 2012)

Classical geography	Criteria of contrast	Modern geography
Historicism	<i>Paradigm's name</i>	Neo-positivism
Regional geography	<i>Tendency /school</i>	Quantitative geography
Regions, places	<i>Study object</i>	Spatial relations
Description of the directly observed physical world (region)	<i>Research aims</i>	Explanation and prediction of spatial relations
Empirical-inductive	<i>General method</i>	Hypothetical-deductive
Classificatory; comparative; historical	<i>Methods and techniques (approach)</i>	Statistics; modelling; correlations
Typologies; particular cases; unique cases	<i>Research results</i>	Generalisations, laws and theories
Monographic maps	<i>Cartographic products</i>	Statistical and correlation maps

or unique cases, meaning that the typologies are only valid for specific spatial units and not for others. On the other hand, the research results of quantitative geography led to generalisations, laws, and theories regarding the spatial relationships or spatial distribution of the phenomena under study. The idea was to apply laws and generalisations that would be valid for all spaces and places. The cartographic products used in both tendencies have also been considered as additional criterion of contrast. As a derivation of the research results, monographic maps have been produced in regional geography, whereas statistical and correlation maps have been made in quantitative geography. The latter products, especially the correlation maps, have been supported by computational and programming techniques.

To summarise: Whereas Table 7.1 establishes the differences between types of sciences, Table 7.2 indicates some criteria for the establishment of trends within a particular science or discipline. These tendencies or schools of thought can be regarded as paradigmatic shifts owing to their contrastive nature in Kuhnian terms (cf. Chap. 3). From an epistemological viewpoint, these trends also support our knowledge of a specific part of reality.

#### 7.4 Comparing Tendencies in Cartography Within the Epistemological Space

A second methodological criterion applied in our investigations is the triangular model derived from Eric Sheppard's discussion about representing critical geography and geographic information systems (GIS). These are related with the three complementary entities empiricism, realism, and idealism (cf. Sheppard 2005). In the field of cartography, Menno-Jan Kraak and Ferjan Ormeling used a triangular figure to characterise geospatial data in their three components: location, attribute, and time (see Kraak and Ormeling 2010).

This triangular model will, for our purposes, be (re)named Tendency distribution in epistemological space. Tendencies mean thoughts, trends, perspectives, and approaches which have been developed within a science or discipline, i.e. geography and cartography. Epistemological space refers to the philosophical and epistemological context that is analysed. In this way, some of the following figures depict the three main underpinnings of the modern period: positivism-empiricism, realism-structuralism, and idealism-hermeneutics. Thus, the triangular model shows how tendencies are distributed within the epistemological coordinates of modernity that frame sciences and disciplines (cf. Azócar 2012).

The paradigmatic tendencies in geography listed in Table 3.2, but this time assigned according to their epistemological space, are shown in Fig. 7.1. The positivism/empiricism coordinate depicted there comprehends three tendencies with a regular distribution: determinist geography, quantitative geography and theoretical geography (left apex). Radical geography is the only tendency along the realism/structuralism coordinates (right apex). A group of six tendencies, however, is distributed along the idealism/hermeneutics coordinates: regional

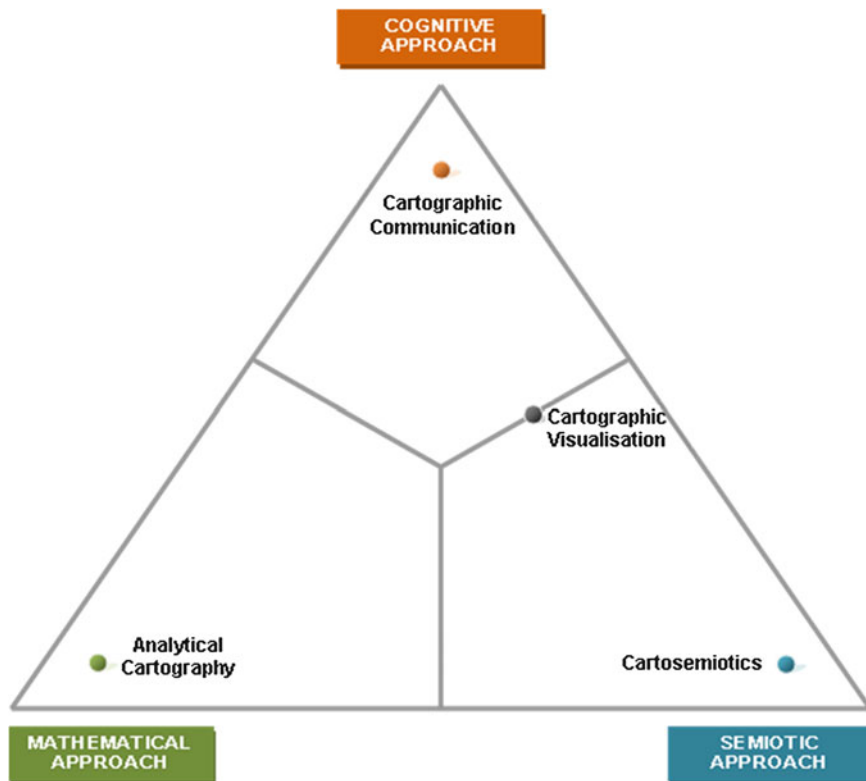


Fig. 7.1 Triangular graph of geographic paradigms (or paradigmatic tendencies) according to the epistemological bases of Modernity (after Azócar 2012)

geography, spatial-temporal geography, and the so-called post-modern geographies. Finally, in the top apex humanistic geography, idealist geography and perception geography are located in a rather concentrated pattern.

In the following, the contemporary tendencies in cartography described in the sections “Tendencies in Contemporary Cartography”, “Critical Cartography in the Context of Post-Modernism”, and “Post-Representational Cartography” are analysed according to the above introduced triangular model with the epistemological coordinates of the modern and post-modern period.

Figure 7.2 is a derivative of Fig. 7.1. It depicts the tendencies that were developed during the second half of the twentieth century, contemporary cartography, according to the three approaches belonging to the scientific-empirical perspective. These are the mathematical, the cognitive and the semiotic approaches. Four tendencies are, with a regular distribution, located inside this epistemological space: Analytical Cartography at the mathematical coordinate (left apex), Cartosemiotics or Semiotic Cartography at the semiotic coordinate (right apex) and Cartographic Communication at the cognitive coordinate (top apex) can be located close to the tips of the

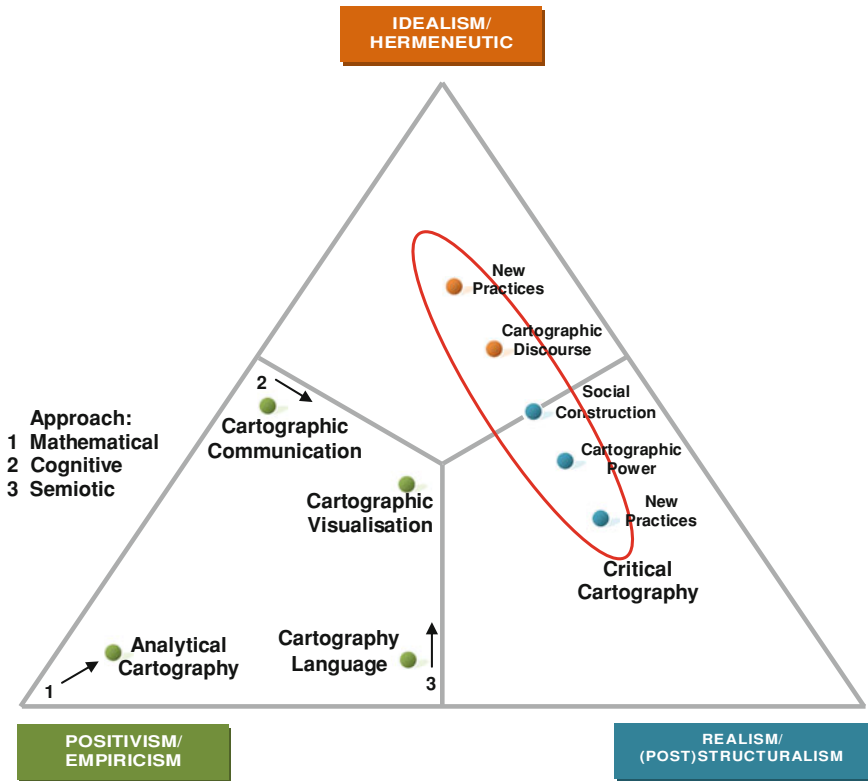


**Fig. 7.2** Triangular graph showing the paradigmatic tendencies in the contemporary cartography (after Azócar 2012)

triangle. The location of Cartographic Visualisation corresponds to the cognitive-semiotic approach, according to MacEachren (1995). In this way, a clear separation of the approaches among contemporary tendencies in cartography can be depicted (Azócar 2012). This will be discussed in more detail in the following chapter.

Figure 7.3 integrates aspects of Figs. 7.1 and 7.2. It shares the epistemological space with Fig. 7.1, however, this time the structuralism axis is replaced by the post-structuralism coordinate. Critical Cartography which pertains during the post-modern period is included. The scientific-empirical perspective belonging to the positivism-empiricism coordinate of Fig. 7.2 has been considered. This perspective contains three approaches: mathematical, cognitive, and semiotic. Thus, the contemporary tendencies in cartography are situated in this part of the triangular model (left apex). On the right side of Fig. 7.3 are, in a concentrated pattern, whose tendencies located which belong to Critical Cartography.<sup>2</sup> Social

<sup>2</sup> This tendency was analysed in the section “Critical Cartography in the Context of Post-Modernism”.

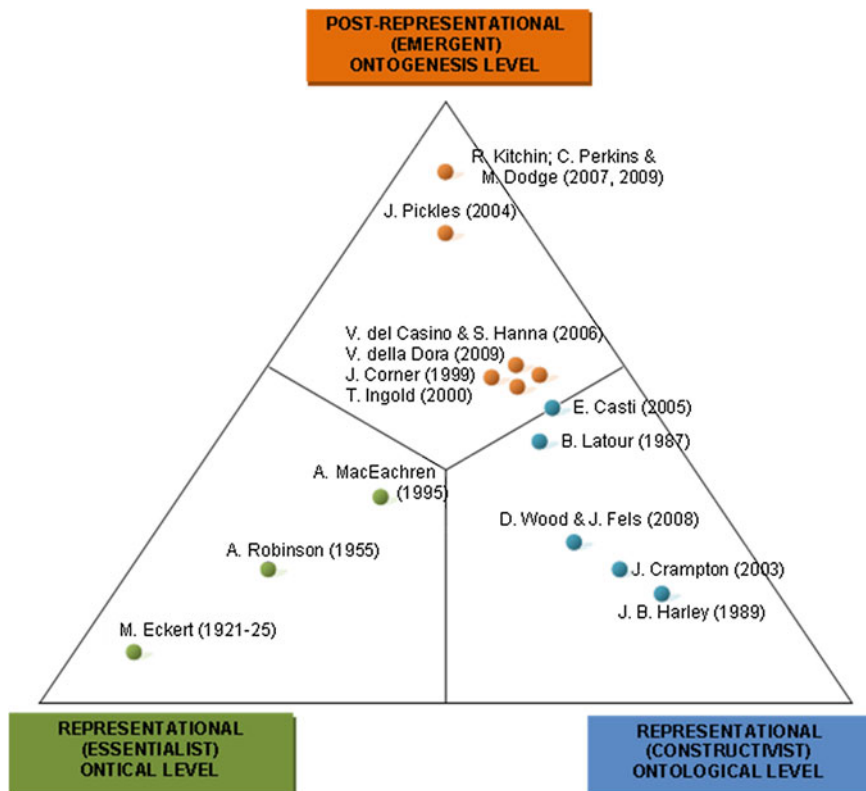


**Fig. 7.3** Epistemological space model of tendencies in cartography during Modernism and Post-Modernism using the scientific-empirical and critical approaches (after Azócar 2012)

construction is shown sharing both the idealism/hermeneutic and the realism/post-structuralism spaces. Next to the social construction, cartographic discourse is located along the idealism/hermeneutics coordinate and cartographic power along the realism/post-structuralism axis. In the same way, new (cartographic) practices are considered sharing both the post-structuralism and the hermeneutics aspects.

A concept similar to that of Figs. 7.1 and 7.3 has been applied in Fig. 7.4. There, however, the three philosophical-epistemological bases of the modern period have been replaced by the ontology security<sup>3</sup> of maps according to Kitchin (2008). This implies a sequence of ontic-ontological-emergent levels. Thus, there

<sup>3</sup> Ontological security is a stable mental state derived from a sense of continuity in regard to the events in one’s life. Giddens (1991) refers to ontological security as a sense of order and continuity in regard to an individual’s experiences. ‘Confidence or trust that the natural and social worlds are as they appear to be, including the basic existential parameters of self and social identity’ (Giddens 1993: 374–377). We consider ontological security as applied to cartography according to Rob Kitchin (2008).



**Fig. 7.4** Epistemological space model of tendencies in cartography during the Modern and Post-Modern Periods making use of representational and post-representational approaches (after Azócar 2012)

is an ontic level which is essentialist within the positivism/empiricism coordinates (left apex of Fig. 7.4). The ontological level which is focused on a constructivist perspective is, similar to the post-structuralism coordinate, located at the right apex. The ontogenesis level which pertains to the emergent coordinate (Pickles 2004; Kitchin and Dodge 2007; Kitchin et al. 2009) is located at the top apex. According to these authors, the Representational Cartography approach would belong to both, the ontic and the ontological coordinates. The new map conceptions that arose during the Post-Representational Cartography,<sup>4</sup> would belong to the ontogenesis coordinates.

Figure 7.4 also shows that Max Eckert's scientific tradition, Arthur Robinson's cartographic communication and Alan MacEachren's cartographic visualisation share the ontic and essentialist coordinates (left apex). This is fostered by the

<sup>4</sup> This approach was analysed in Chapter "Post-Representational Cartography".



philosophical, ontological, and epistemological underpinnings of the scientific-empirical approach.

Furthermore, Fig. 7.4 summarises stances taken by authors who draw from social theory and human geography which have been applied to cartography and mapping (right apex). This is the case for John B. Harley's legacy and a group of his followers who belong to critical cartography. In this way, Harley, Jeremy Crampton, and Denis Wood and John Fels are in a concentrated pattern, located at the centre of the ontical-ontological coordinates. Similarly, there are also some authors in the critical studies context that can be classified in a transitional stage between the ontical-ontological and ontological-ontogenesis approaches (e.g. Emanuela Casti and Bruno Latour). In this transitional space, a group of thinkers including James Corner, Tim Ingold, Vincent Del Casino and Stephen Hanna, and Veronica Della Dora are also located (cf. right side of figure). They all occupy an intermediate position between representational and post-representational cartography, displayed in a concentrated pattern.

Some other authors consider cartography with a post-representational stance: especially John Pickles who is followed by Rob Kitchin, Chris Perkins, and Martin Dodge (cf. top apex of Fig. 7.4). Within the epistemological space model, they form a different grouping with respect to other stances. The proposals of these thinkers are under an *emergent knowledge* approach in the ontological-ontogenesis transition coordinates.

However, it should be mentioned explicitly that today in cartography, and in particular in geoinformatics, the term ontology is frequently applied in a different way than initially used in analytical philosophy. This is, in part, due to misinterpretations in publications of the early years of the 21st century, like Kitchin et al. (2009). According to Zsolt Török (courtesy written communication 2012) we want to emphasize that ontology must not be explained in terms of epistemology. Such a wrongly materialised interpretation leads to a problematic concept of representation in science, so to the concept of science as 'the mirror of nature'. By 1989, i.e. 12 years before Crampton (2001, 2002), Török suggested *historical social ontology* as the theoretical basis for a 'new' cartography (Török 1989). This approach is still open to the community interested in theoretical cartography research.

To conclude, using the triangular graph of Fig. 7.4 it is possible to locate the different cartographic tendencies within the epistemological space of contemporary cartography and post-modern period. The distribution of these tendencies inside the figure, i.e. their concentration-dispersion pattern, permits the identification of some paradigmatic shifts (or their absence), according to the scientific communities of the Kuhnian terminology. This aspect will be deepened in the next chapter.

## 7.5 New and not so New Epistemological Crises in Cartography

To mention it right away and explicitly: The following deliberations draw extensively on an article by the German scientist Marion Picker in a book co-authored by her (Picker et al. 2013) where she as a studied media scientist, anglicist, germanist *and* philosopher quite profoundly—however logically from the viewpoint of an expert in humanities—dealt with paradigmatic changes in cartography.

Almost 90 years after the seminal statements of Max Eckert ‘to establish theoretical cartography as a science’,<sup>5</sup> in his article about the future of cartography Alexander Wolodtschenko casually asked the question whether cartography is *still* a science (Wolodtschenko 2009).<sup>6</sup> The implicit answer is, though: yes; but for the remainder several reasons are given why scientific cartography runs the risk to become irrelevant, i.e. due to its ‘methodical-conceptual deficits’ which have to be assigned to the predominance of applications, applicabilities and technologies over theory (Wolodtschenko 2009: 45; cf. Koch 2004: 5). Already Max Eckert admonished not to leave cartography to the ‘technologists’ (Eckert 1921: 2; cf. also Glasze 2009: 181, 187). Eckert’s oeuvre per se, however, demonstrates how far future-oriented questions are just emerging from the interpenetration of technological, historical-cultural and epistemological aspects (Picker 2013: 8).

Other than Wolodtschenko (2009), Denis Wood located the “problem” of cartography at those who consider themselves as the scientific guardians of cartography. Drawing on the famous French formula<sup>7</sup> and a low pun by Friedrich Nietzsche, in his seminal paper “Cartography is Dead (Thank God!)” he welcomes the end of the exclusive pretensions of the academic and merely professional cartography to the relevant map knowledge. Wood claims that geoinformation systems and their successful commercialization actually lead to a redefinition of cartographic competence. Despite Wood’s commitment to the “classical” principles cartographic technology, he is rather inclined to vote for a high-quality “map making” (Wood 2003: 6). Wood appreciates a simply scribbled sketch map not less than a map which satisfies all scientific requirements. Together with John Krygier he even issued a Web-based sort of tutorial or manual: <http://makingmaps.net/> (cf. Krygier and Wood 2005; Picker 2013: 8).

Not only according to Picker (2013) several authors sense a certain crisis of cartography at the beginning of the 21st century (cf. amongst others Hruby and Guerrero 2008: 1, 7 and Crampton 2010: 4). *However*, there exists general consent that the “age of space” Foucault (2005: 931) has not yet begun to cease, and hence also the generation, use, thematisation, historisation and re-invention of maps. Marion Picker (2013: 9) tried to investigate into the amazing relation between the

<sup>5</sup> “... die theoretische Kartographie als Wissenschaft zu begründen ...” (Eckert 1921: III, drawing on Eckert 1907).

<sup>6</sup> “Ist die Kartographie noch eine Wissenschaft?” (Wolodtschenko 2009: 58).

<sup>7</sup> ‘Le roi est mort, vive le roi!’.

still existing popularity of maps and the asserted or supposed crisis of cartography. Stating that while during the 1960s in cartography a structuralistic, semiologic and communication-scientific change occurred (cf. Bertin 1967 and Freitag 1980, 2001), she sees at the beginning of the 21st century competitive situations coming up due to the various extra-scientific developments. The possibilities of *Web 2.0 Cartography* caused specialized knowledge that is now maintained by disciplines like geoinformatics or (geo)visual analytics, thus claiming even parts from the core of the research area of traditional cartography (cf. Hruby and Guerrero 2008: 9).

It is interesting that a new conceptualization of cartography takes its motivation exactly from what is by Picker (2013: 9) considered its crisis. It develops, like in Jeremy Crampton's book, a critique of both map and cartography, recently also including "critical GIS studies" (Crampton 2010). As also pointed out by Marion Picker, this *critical cartography* that developed in the Anglo-American world since the 1990s, in particular due to the reception of Brian Harley's publications, not only investigates the discursive conditions of map production in and on maps but also maps as models and programmes for social and political processes (cf. Picker 2013: 10). This critical attitude has by no means being a matter of academic concern only. According to Cosgrove (2005: 27) the diversity of cartography has primarily to be attributed to the *cultural turn* occurring, one way or the other, in almost all human and social sciences within the aforementioned time. In this context maps are considered as diversified practices within their historical changes (Picker 2013: 10).

As mentioned elsewhere in this book (cf. Sect. 5.5), in the first volume of the multi-volume *History of Cartography* Brian Harley and David Woodward take these developments into account by defining maps in a general, rather descriptive than prescriptive manner in the following formulation: 'Map are graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world'<sup>8</sup> (Harley and Woodward 1987: xvi). Denis Cosgrove, who has actually also been in favour of the term *mapping(s)* (Cosgrove 1999, 2005), attribute much of the "*fashionable fascination*" of maps to this epoch-making work *History of Cartography*.<sup>9</sup> Trying to differentiate *mappings* from *maps* (which he does not accomplish very rigorously) he turns against various fields of cognition science that, through terms like *cognitive map*, *mind map*, *concept* or *semantic map*, decisively contributed to make alternative conceptual characteristics of maps known and to circulate them (Cosgrove 1999: 3). In his 1999 publication book he points out that in the end every mapping process is necessarily also a cognitive one (Cosgrove 1999: 7) and, hence, cognitive maps are

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<sup>8</sup> To the authors' opinion this definition certainly has to be extended by the *natural world* as well as *other celestial bodies*.

<sup>9</sup> Since for Cosgrove the graphic and representative qualities are crucial criteria of a map's nature ("*Kartizität*" Picker 2013: 12), he also includes narrative, literary route descriptions but also abstract geometric compositions in his far-reaching/broad/wide/widely formulated/broadly formulated definition (Cosgrove 1999: 1, 17).

subject to determinative discursive conditions. In a 1996 paper in the map-historical Journal *Imago Mundi* Matthew Edney writes:

One of my favourite instances of how the idea of the map is accepted automatically is provided by educational and psychological theorists in the United States. Numerous scholars have written extensively on what they refer to as ‘semantic mapping’ [...] Despite the evident importance of the map as a metaphor for the concept, their literature seems to contain no discussion of what ‘mapping’ is. The sub-discipline as a whole is underpinned by an unexamined assertion, and authors rely on the communal understanding of what maps are. (Edney 1996: 187).

If, as Picker (2013: 14) sets forth, *cartography* has traditionally been defined as the technique of map making, the knowledge about and history of maps as well as their entirety, and *maps* as cartography’s object, at the turn of the 2000s to the 2010s both concepts are converging. The insecurity about the decisive criteria of the nature of a *map* is increased by the new technological possibilities for the production, storage, communicability, and visualisation of spatial data. As the statements by Harley and Woodward (1987) as well as Cosgrove (2005) showed, all parameters that traditionally played a role in map definition, like format and material, extension of depicted region, the map’s “visibility”, its geographic names and lettering in general, the overall design, scale (be it numerical or graphic), map frame, geometric grid etc. gained new terminological “fuzzinesses” and were called “instable” by Picker (2009: 15).

Credits belong to Marion Picker that, based on her humanities background, she managed to link the above statements with the psychoanalytical aspects which—surprise, surprise!—have some relation to maps (cf. Picker 2013: 15, 16). It is by any means remarkable that Sigmund Freud, when discussing a possible reconciliation with *culture*, the main point in his publication ‘*Die Zukunft einer Illusion*’ (‘*The Future of an Illusion*’), used a geographic-cartographic example to describe a type of knowledge resp. science that is *without illusion*, i.e. not determined by desires and fears. Freud claims that, in contrast to religious dogmas, for geographic theorems it is possible and sufficient to make a personal check. A simple journey, so Freud, suffices to verify the tenets depicted in a map. He gave the example “Constance is situated at Lake Constance”,<sup>10</sup> a saying that is since Freud’s use well-known in the German-speaking region. Using the statement “The beautiful town is located at the banks of a large body of water that all local residents call Lake Constance”<sup>11</sup> he discloses, however, at least indirectly, that the principle of self-verification/individual checking can in many cases be problematic, in particular in cartography. The pivotal criterion is based upon hearsay or second-hand knowledge: what seems to be natural, is merely denominative convention; a finding which may be known to every mapping cartographer who ever did her/his work in unfamiliar remote areas where no reliable maps exist (cf. Buchroithner 2011: 24, 25, 31).

<sup>10</sup> “Konstanz liegt am Bodensee.” (Freud 1974: 159).

<sup>11</sup> “Die schöne Stadt liegt am Ufer eines weiten Gewässers, das alle Umwohnenden Bodensee heißen.” (Freud 1974: 159).

## 7.6 Autostereoscopic True-3D Cartography: Another New Paradigm

Immediately before and soon after the turn of the millennium, a series of papers initiated and authored by a cartographic 3D-visualisation group at the Dresden University of Technology, Germany, indicated another paradigmatic development in cartography: the advent of the third dimension in the form of stereoscopic perception using physically flat lenticular foil maps (Buchroithner 1999; Buchroithner and Schenkel 2001; Buchroithner et al. 2000, 2004a, b, 2005a, b, c). These flat maps allow the *spontaneous* stereoscopic vision *without any viewing aids*: This is called *autostereoscopy*. Much of the knowledge gained through these developments, which were unfortunately a little bit unnoticed by the global cartographic community, has been summarised in a monograph by Thomas Gründemann (Gründemann 2004) and then, in a comprehensive form, been published in a seminal journal paper entitled “True Three-Dimensionality in Cartography: Yesterday, Today and Tomorrow” (“Echtdreidimensionalität in der Kartographie: Gestern, heute und morgen”; Buchroithner 2007).

There were, however, precedent attempts made to introduce true-3D cartography by means of autostereoscopy, in these cases by means of holography: at the 19th International Cartographic Conference in Ottawa in 1999 the first actual holographic map<sup>12</sup> was presented to the global cartographic community. This whitelight hologram even allowed the viewing, in a flip mode, of the unlabelled ‘pure’ landscape or the landscape plus the geographic name tags hovering above the terrain and thus (cf. also oral communication by Harold Moelling 1999) represents the first actual holographic map (Buchroithner and Schenkel 1999; Kirschenbauer and Buchroithner 1999; Buchroithner 2000). The extensively high production costs for both ‘simple’ holographic stereogrammes as well as ‘real’ cartographic holograms finally abandoned further developments into this direction for a while (see next paragraph) and fostered the ‘triumph’ of lenticular foil technology (Buchroithner and Knust 2013). A further enhancement of this new trend was reached by displaying three different scales in a three-in-one flip mode ‘flying carpet approach’ where part of the depicted landscape is represented at a large scale in smaller maps hovering above the terrain (Buchroithner et al. 2005a, Buchroithner 2008). The multitemporal domain was also added to this true-3D cartography by displaying two or even three instants of time in one lenticular foil map in a stereo-flip mode (El Nabbout 2007; Bruhm et al. 2010).

Within the first decade of the 21st century, however, holographic relief-map production got a new boost in the non-civilian domain. Apart from a few groups in

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<sup>12</sup> By, 1985 the Canadian R. Simard from the Canada Center for Remote Sensing (CCRS), together with the MIT Professor of Media Arts and Sciences, Stephen A. Benton (1941–2003), produced an achromatic holographic stereogram out of Landsat multispectral scanner data. This, however, was only a sort of stereoscopic image without any further cartographic information like geodetic grid or name labellings.

North America, a young team in Turkey has been pushing these developments. Thus a revival of actual holographic maps may be expected in the years to come (cf. Dalkiran et al. 2009, 2012). Whether this technology may lead to another real shift in the paradigms of cartography in the long run, due to the direction-independent viewing of “virtual landscapes”, remains to be seen.

Parallel to the ‘hardcopy approach’, digital autostereoscopic display technologies have also been used for cartographic purposes (‘softcopy stereoscopy’; Buchroithner 1998; Buchroithner et al. 2000): In 2001, at the 20th International Cartographic Conference in Beijing, conception and prototypic realisation of an interactive true-3D atlas using an autostereoscopic display developed at TU Dresden, Germany, (Liehmann 2003) was presented to the global cartographic community. In the appraisal of it during the best map awards ceremony, this has been described as another quantum leap in cartography—at least regarding the representation of the third dimension.

Although the use of autostereoscopic electronic displays has mainly been demonstrated with georelief, thematic phenomena were also the subject of research and development using autostereoscopic displays after the year 2010 (Bröhmer et al. 2012). They proved to have a significant potential, in particular for educational purposes (Dickmann et al. 2012).

Modern Web technologies also allow for the long-distance real-time distribution of truly three-dimensional geodata (Buchroithner et al. 2012; Sanchez 2012). Even smartphones with touch-screen functions can, since 2010, display geodata in general and maps in particular in a lenticular foil-based way in an autostereoscopic way (Buchroithner 2011).

All these developments were also accompanied by profound theoretical considerations in various ways, which are spread over the aforementioned publications (primarily Buchroithner 1999; Buchroithner and Schenkel 2001; Buchroithner et al. 2004b), and amongst others that also lead to Buchroithner’s postulate to extend the semiological system of Jacques Bertin into the third dimension (cf. i.a. Buchroithner and Böhm 1998; Buchroithner et al. 2004b). In hindsight, it seems surprising that so far, it has hardly been stated in the disciplinary literature that the above mentioned technological developments actually also triggered another notable paradigmatic change in cartography.