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Concepts of Central Place Research in Archaeology

By Oliver Nakoinz

Introduction

This paper deals with central places in the sense of Christaller (1933). Since the early 1990s the central place theory is a very common theoretical concept for the exploration of extraordinary settlement sites. These applications generally use a small spectrum of methods and ideas from the original central place theory. Especially the model of hexagonal territories and the analysis of the optimisation of different parameters is not a conception which is useful in archaeology.

In practice, the restriction to the core of central place theory often leads to a hunting of central places without a further analysis of the corresponding settlement structure. More and more settlements become central, so that nearly all settlements seem to be some kind of central place. In addition to the identification of extraordinary places, the central place theory holds a strong potential for analysing the hierarchy of settlements and structure of settlement patterns. However, advanced applications of central place theory in archaeology are uncommon.

In this paper I want to present some ideas for a systematization of central place research in archaeology. It has to be emphasized here once again, that this systematisation is limited to central places in the sense of Christaller. The relationship to other concepts will be discussed briefly and is the topic of other papers in this book.

The starting points of the following deliberations are the princely sites from the early Iron Age, which were investigated by a DFG priority project (SPP 1171; Krausse 2008; Nakoinz / Krausse 2005; Nakoinz / Steffen 2008) and occur in many examples.

Central Place Theory in Archaeology

The first applications the of central place theory in archaeology occurred decades after Christallers (1933) first publication of his concept. A short history of research can be found in Müller-Wille (in print) and Steuer (2007). The origin of the application of the central place theory in archaeology is to be seen in Haggett's book about geographical locational analysis from 1965. British New Archaeology (Clarke 1977; Hodder 1977; Hodder / Orton 1976; Orton 1980 and Renfrew / Level 1979) has perceived Haggett's book and the central place theory with it. The British applications are focused on reconstructing territories using Thiessen polygons.

Since 1989, the central place theory has been very popular in Scandinavian archaeology (Brink 1996; Fabech / Ringtved 1995; Hansen 2003; Hårdh / Larsson 2001; Larsson / Hårdh 2003). Here the problem of regional structures in connection with some extraordinary sites was the starting point to investigate central sites. Coming from this point, the identification of central places forms the main task of the Scandinavian central place research (Fabech 1993; Fabech 1999; Fabech / Ringtved 1995). Nevertheless, the theoretical foundation of archaeological central place research has been improved in some works (Hansen 2003).

In Germany archaeological central place research is a very heterogeneous field. Early publications Fehn (1970), Denecke (1973) have not been taken up for further analysis. It was not until the late 1980s – the same time when the central place theory came up in Scandinavia– when Kunow (1988, 1989) and Mangin (1987) drew attention to central place theory. The breakthrough of central place research in Germany is marked by an article by Gringmuth-Dallmer in 1996. In Germany central place theory archaeology focuses on the idea that central places provide special functions for their territories (Gringmuth-Dallmer 1996). Included in the list of functions are power, security, trade, production and cult.

Since we generally cannot estimate the supply of different goods from a certain market place only by archaeological sources, the usage of central functions is a good choice. In the following years, this concept

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dominated the central place research in Southern Germany (Krausse/Nakoinz 2000; Krausse 2008) while in Northern Germany central place research is mainly oriented on the Scandinavian model (Hardt et al., in print). The usage of Christallers original term 'Zentralort' in Southern Germany and 'Zentralplatz' in Northern Germany as reimportations via Scandinavia and the British Islands are indicators of the different traditions. In France the central place theory has also been discussed (Chaume 2001; Olivier/Wirtz/Triboulot 2002).

Christallers theory contains a component which is less useful for archaeology because of our incomplete sources. This component models the optimisation of different parameters. The best way to distribute settlements of the same hierarchical level in space is a regular pattern with octagons as territories. The optimisation of distance, traffic or borderline leads to different locations of the subordinated settlements in the system of octagons which corresponds to a so-called k-value. We could use the settlement pattern to identify the parameter which has been used for the optimisation.

In the sense of Christaller central places provide their 'territories' with central place functions and obtain their prominence from this area. This simple and powerful definition implies some important advantages for archaeology:

1. Abstraction: It is not based on concrete functions but an abstract concept. We can adapt the theory to our sources by choosing functions which can be indicated by archaeological finds.
2. Integration of different paradigms: Some of the older paradigms are integrated in a natural way. Most of the aspects which were discussed concerning princely sites are central place functions in the central place theory. For example, the concept of princely site, port of trade, production site and ritual centre are included in the concept of central places.
3. Complex models: The theory of central places suggests not only to identify central places, but to integrate central places in complex models.
4. Integration of centre and periphery: Not the central place itself but the relation of core and periphery is of interest.

Central place theory in geography (Christaller 1933; Heinritz 1979) was abandoned in the 1980s (Blotevogel 1996). Today a paradigmatic shift towards a network model is propagated (Meijers 2007). We will see that the central place theory and network models are not alternative but complementary concepts. In the future Christallers theory could come up again in connection to the 'new economic' geography (Güssefeldt 2005).

The following pages are dedicated to the different concepts of central place research and their specific methods. We can distinguish some main tasks which may be subdivided into several points.

Identification of Central Places

The first step on a path to systematic analysis is the identification of central places. Kimmig (1969) defined the princely sites with a list of archaeological indicators some decades ago. These indicators are:

- fortification (suburbium und acropolis)
- import (Greek vases …)
- elaborated pottery with foreign influence
- gold, silver
- other precious materials (amber, coral)
- rich tombs
- bronze vessels
- wagons

A similar concept is in use in Scandinavia (Fabech/Ringtved 1995; see below).

For detecting central functions we can use the same finds and features which were used as indicators of princely sites in a traditional hermeneutic approach. For example, trade is indicated by imports, power by rich tombs and security by fortifications. Counting central functions instead of indicators of princely sites leads to different weights of the central places and may have some advantages for the reconstruction of hierarchies.

Territories

Now we can try to find the territories of the central places. Analysing territories and borders is a very important methodological item in current analytical archaeology (Garcia/Verdin 2002; Müller 2006; Nuninger et al. 2006; Svanberg 1997).

There are two fundamental concepts: construct ing ideal territories and reconstructing real territories. The first concept only analyzes which territorial division is the best for a set of central places and some additional conditions, while the second concept answers the question how the territories really could have been. Therefore, we generally need much more information, especially from the space in between the central places.

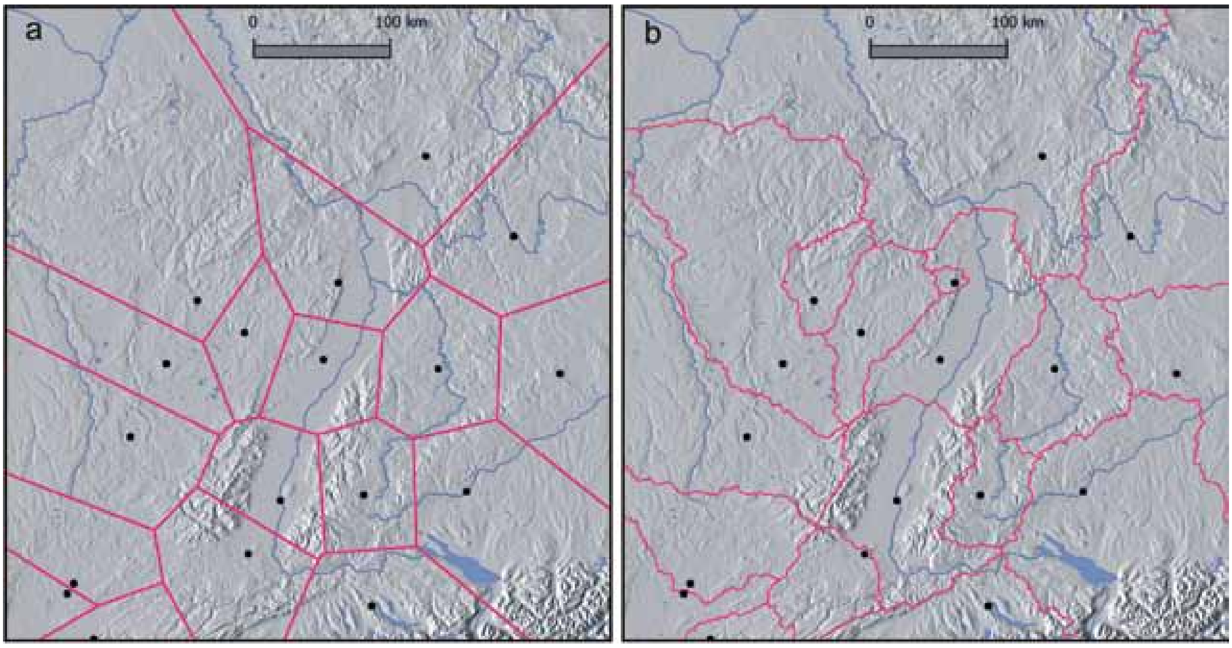

Fig. 1. Thiessen polygons of the ‚Fürstensitze' from the early Iron Age. a) Euclidean distance in a plane; b) costs of transport, calculated on the basis of relief.

We will start the construction of ideal territories. A method which only uses the location of the central places is the calculation of Thiessen polygons (Härke 1979; Olivier/Wirtz/Triboulot 2002; fig. 1.1). The borders are formed by the points which have the same distance to the nearest central places. The distance used here is the Euclidian Distance in a plane. The topographic relief has no influence on the result. If we consider the geography, we can use the cost of transport instead of the Euclidean distance. This results in a map with nonlinear borders (fig. 1.2) which seems more realistic than simple Thiessen polygons.

In the case of the very small territory of Bad-Dürkhein opposite to the mouth of the Neckar we can see the influence of the local relief to the resulting tessellation map. In cases of a bad location of the representative point of the site or a very heterogeneous local relief the territories can be smaller than the expected and presumably true territory.

These methods presuppose an equal weight of each central place. There are no settlements which are bigger than other ones with a larger territory than smaller settlements.

The information which makes a difference between the settlements can be included in the calculation. The methods we obtain are for example: additively weighted Thiessen polygons (Okabe et al. 2000), the Xtent model (Renfrew/Level 1979) and the Fetter model (Fetter 1924). The density cluster analysis (Herzog 2009) is a related method, which does not result in borders but in the assignments of subordinated settlements.

The formula used here (Fig. 2) tries to cover all these methods and is a generalised version of weighted voronoi polygon analysis. The formula gives us the option to use several variables and thus to apply complex models. Φ is the influence from a certain central place. The first term gives us the additive weight and the second term the multiplicative weight. Each weight has a static as well as a dynamic component and a Boolean variable which switches between these types of weights. The dynamic weight has different values for all central places while the static weight has only one value. The last term is the Euclidean distance, which could be substituted by the relief friction.

Some examples shall visualize the concept of weighted voronoi analysis (Fig. 3). The map shows the polygons for early Iron Age central places for three time-slices (columns) and different parameters (rows). The sites are weighted by the number of rich tombs

$$\Phi = \alpha_s \left(t_\alpha \alpha_d + |t_a - 1| \right) - \gamma_s \left(t_\gamma \gamma_d + |t_\gamma - 1| \right) \psi \left(\sqrt{(x_z - x_p)^2 + (y_z - y_p)} \right)$$

Fig. 2. Formula for the calculation of generalized weighted voronoi polygons.

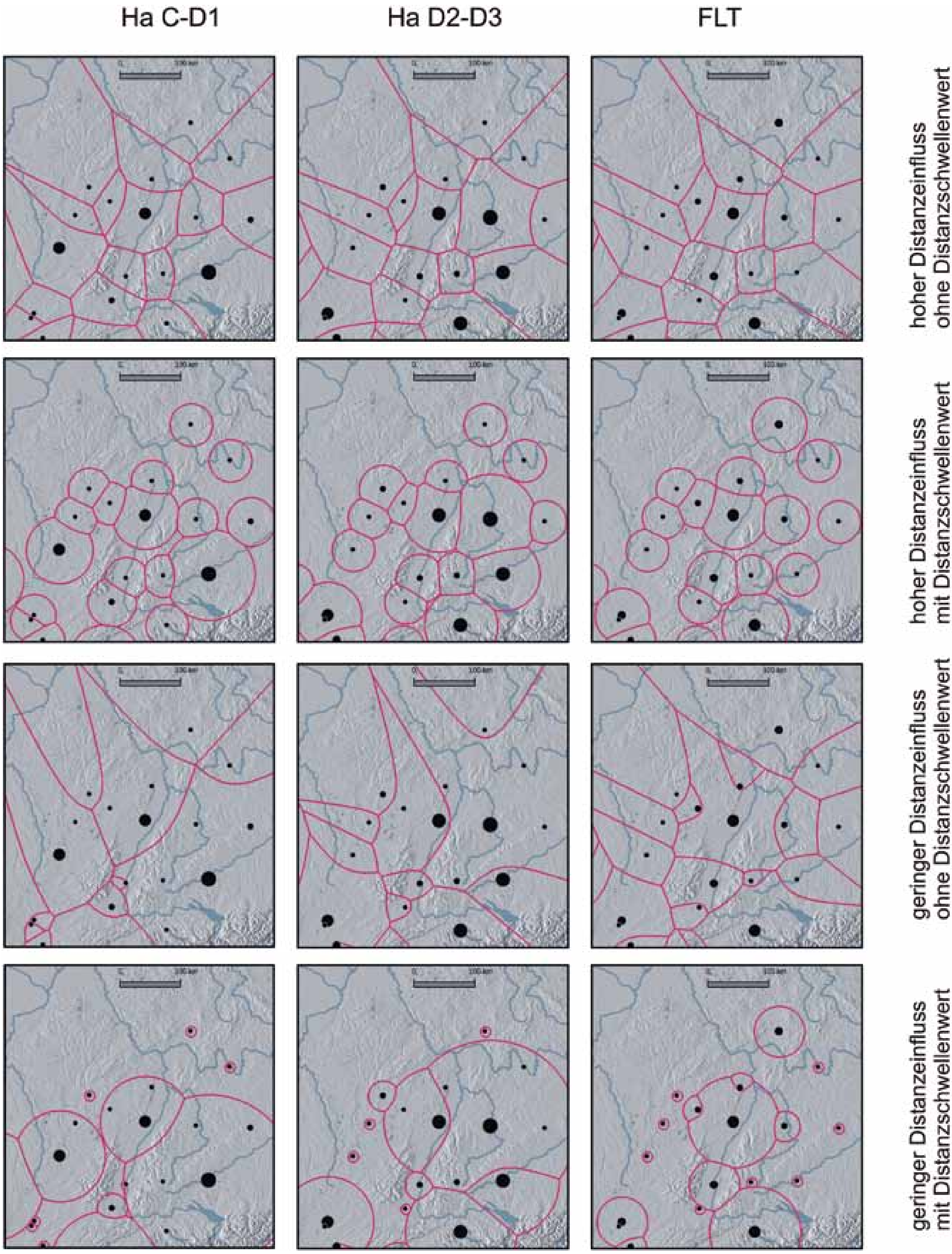

Fig. 3. Weighted voronoi polygons of the ‚Fürstensitze' from the early Iron Age, weighted by the number of rich tombs.

from the surrounding area of the central places. This weight is not a useful value, since not the number, but the content of the graves should correspond to the size of the territory. Nevertheless, it gives us a very instructive example. The rows in Fig. 3 differ by the parameters. The second and fourth rows use thresholds of influence to delimit the territories. This leads to a maximal distance which depends on the additive weight. In the third and fourth rows we can recognize hierarchies since some central places are assigned to superordinated sites.

A further concept is to use topographic features as indicators of borders. One example is the usage of watersheds (Löwenborg 2007). In a society which is focused on water transport this is a useful method. In a society which is focused on control, an analysis of view (Posluschny 2008; Steffen 2008) could make sense. In this case we have to prove, that it was really necessary to see the whole territory and that a system of connected points was not sufficient.

Up to now is has only been calculated how the territories would be good, not how they have been. The reconstruction of real territories generally requires more information than the location and features of the central places. A simple method which is classified as reconstruction because an empiric parameter is used, is the concept of standardised diameters of circular territories (Brun 1988). We could think that the territories should have a certain diameter which is delimited by other territories. In this case one can get the diameter by analysing the distance to the nearest neighbour. But first we have to prove that the distribution is not stochastic, but ordered. The g-function is a useful tool to do this (Bivand / Perbsema / Gómez-Rubio 2008, 161 – 162). This function is the number of points with a lower distance to the nearest neighbour. In our example the empiric curve is similar to the theoretical curve for stochastic distribution (Fig. 4). Therefore, our princely sites have no standardised distances and we cannot suppose circular territories with the same diameter.

A better concept is to use the distribution of all settlements or sites for the reconstruction of settlement areas and border zones. There are some methods which all use the density of settlements as a parameter. Some are focussed on finding borders and others on finding settlement clusters. A very simple method classifies the whole area in a partition with settlements and a partition without settlements ('Ödmarken'; Jankuhn 1961). An improvement is to use the density of settlements (Fabech 1993, Zimmermann et. al. 2004), which can be visualized as a relief or as isolines. The analysis of density clusters seems to be the most advanced method of this group (Herzog 2009).

For finding borders one can also use border indicating monuments. Functional indicators are fortifications (limes, hillforts). Graves and boundary stones can be semantic indicators. Megaliths are supposed to be demarcations of borders (Renfrew 1973). The dominant interpretation of barrows from the Bronze Age is that the tumuli are arranged along ancient path ways.

In addition, we can use significant types of finds which were used as semantic markers. We suppose, that the distribution of significant types indicates

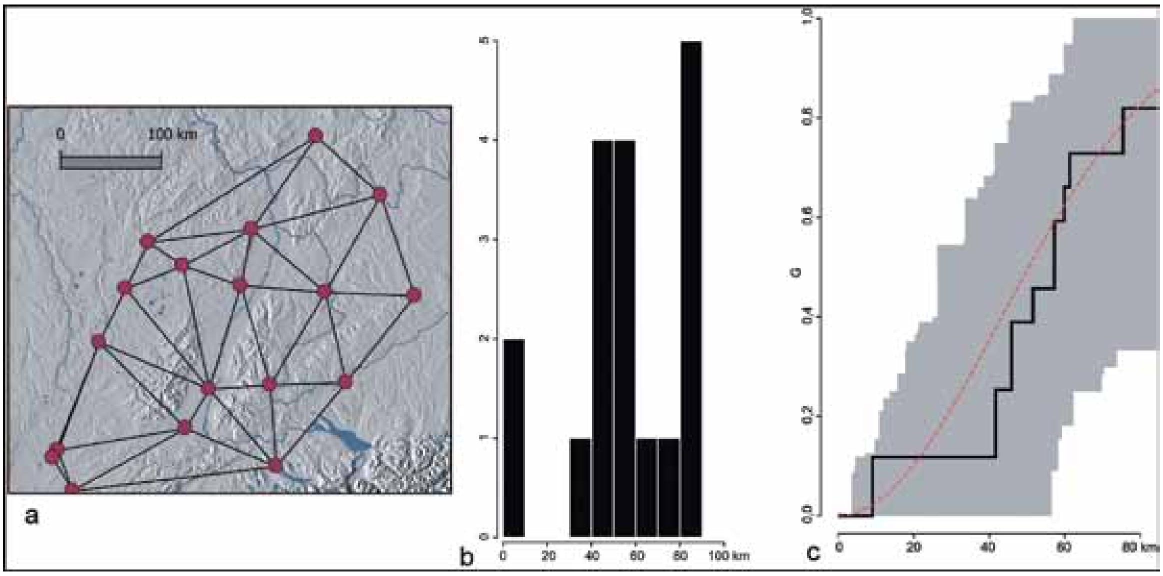

Fig. 4. Territories with standardised size? a) Delauny polygons of the ‚Fürstensitze' from the early Iron Age. b) Histogram of the distance to nearest neighbour. c) empiric (solid) and theoretic (dotted) g-function of the distance to nearest neighbours and the envelope.

the extent of the territories. Several methods of analysing territories with point patterns of significant types are shown in Fig. 5. Territories which are indicated by two types of Hallstatt ceramics (Fig. 5a) were reconstructed. In these examples we want to differentiate the territories of both types of ceramics.

First, one can interpret the whole area which is covered by a type as corresponding territory. For this task a convex hull (Fig. 5b) is calculated. The huge area in which the two territories are overlapping makes clear that this is not a useful method. The results of using a buffer around all find spots is much better (Fig. 5c). The overlapping area is small. But it also has its disadvantages. We don't want to include single find spots like those to the north and to the east of the territory. We can exclude them by using the density of points. Fig. 5d shows the density as isolines and the areas of a high gradient which can be interpreted as border zones.

The concept of border zones does not seem to be ideal for our task. We can try to use a single isoline of density as a border (Fig. 5e). We can also gain overlapping territories with a size determined by the selected isoline.

Finally, we can use the ratio of density of different types (Fig. 5f). The border between two territories is defined by a certain ratio so we don't get overlapping areas. The outer border is also defined by this ratio, which prevailing, corresponds to a certain isoline of density. In a generalised form, we use the quota of a type instead of a ratio of two types.

Other methods, for example patch analysis from ecology, are not discussed in this paper (Jacuez / Maruca / Fortin 2000; Lang / Blaschke 2007).

For the reconstruction of ethnic areas we need a special type of significant types. This type is an ethnic marker, concentrated near the border and used to delimit to other people (Siegmund 2000; 2009).

Significant types have many disadvantages. First we have to know which type is significant. We have to suppose this because significance is the result of an analysis which we have not done. If we know which type has the highest significance, and we are restricting the analysis to this type, the result may also be wrong. Using significant types is generally not useful.

Instead of significant types we use 'Typenspektren' (Fig. 6; Nakoinz 2005; 2009). Typenspektren are the compilation of all types or all types in a category. The hierarchical classification of finds leads to a sawtooth shape of the histogram. Using Typenspektren allows us to apply the concept of a cultural metric. We can calculate a distance between two Typenspektren which we can interpret as a cultural distance. We suppose that the existence of a territory leads to a homogeneous culture. Thus, one can reconstruct the territory by finding similar Typenspektren. For grouping similar Typenspektren we use a cluster analysis (Nakoinz 2005).

The advantages of using Typenspektren instead of significant types are visualised in Fig. 6:

- Differentiation of areas of dispersion by quantification;
- Evaluation of the significance and the detection of cultural groups which only depend on an insignificant type;
- Calculation of the degree of membership;
- Construction of hierarchies.

Hierarchies

Up until now we have presumed, that no central place is dependent on another one and their territories are disjunctive. In reality there may have been hierarchies. The distribution of the size of settlements or the size of necropolises as proxies can give us an indication of hierarchies (Hennig / Lucianu 2000; Olivier / Wirtz / Triboulot 2002; Müller-Scheessel 2007).

Reconstructing hierarchies is a common task of social archaeology. In most applications several levels of a predefined social hierarchy are indicated by special types of archaeological finds. The same principle can be applied on settlements. In Scandinavia a settlement hierarchy with three levels is in use (Fabech / Ringtved 1995).

Principally a hierarchy does not only consist of a ranking of items or a classification into several levels. An assignment of subordinated items to superordinated items is also necessary. In practice the assignment can be done with the help of the analysis of territories. In each territory the settlements can be assigned to the one with the highest ranking (Fabech 1993). A similar method is using a distance weighted assignment which is nothing but using weighted voronoi diagrams (Nuninger et al. 2006).

A further method for finding hierarchies is a hierarchic cluster analysis (Fig. 7). We can apply a hierarchical cluster analysis to Typenspektren. The hierar chic relations are represented by the dendrogram. The interpretation of the dendrogram can be supported by some structural key numbers which evaluate the nodes in the tree of the dendrogram.

For some years the discussion about polyhierarchies and heterarchies has been en vogue (Becker 2005; Crumley 1995; 2005). The idea of polyhierarchies is that the hierarchies of different central functions which are supplied for territories are not

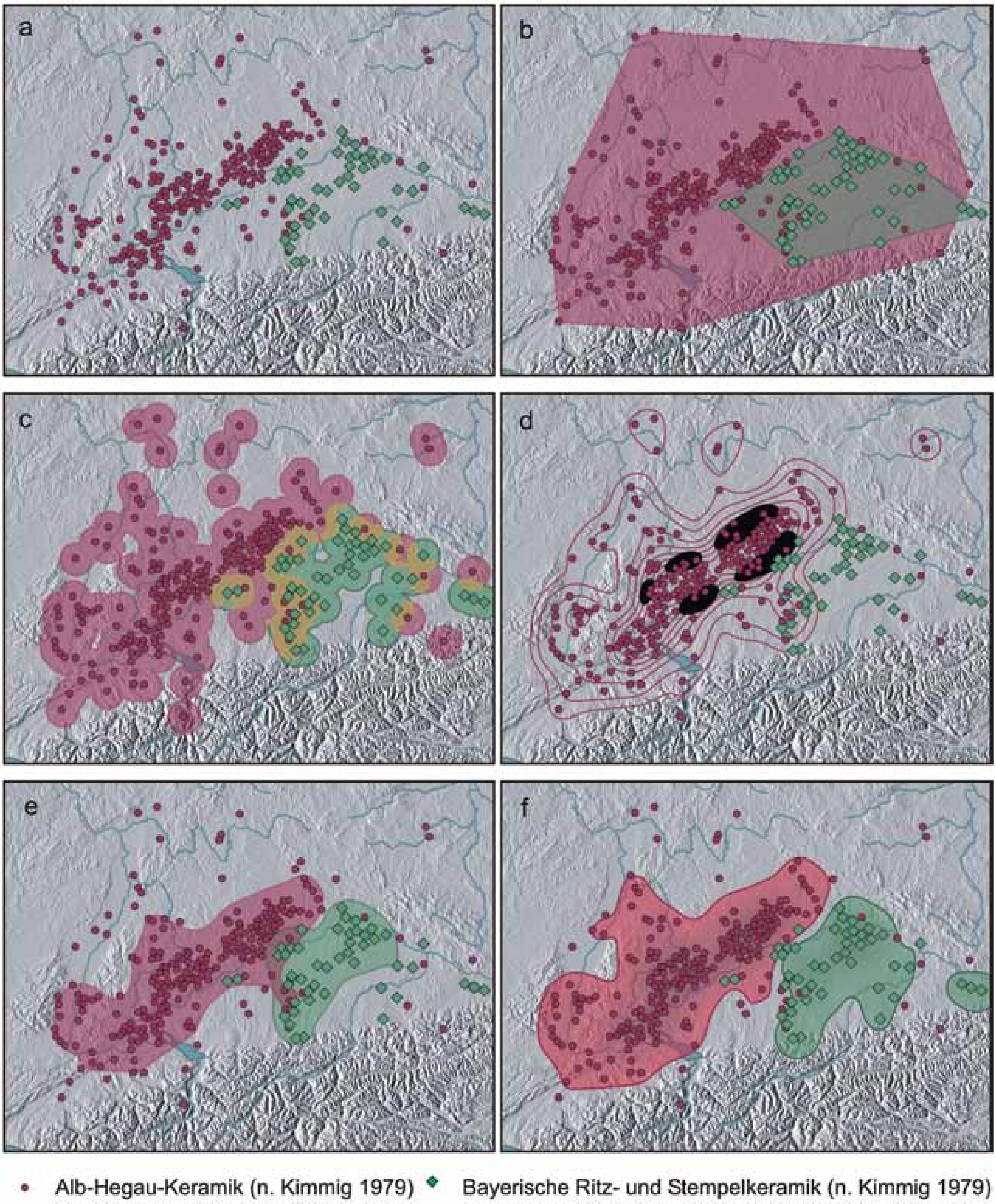

Fig. 5. Territories represented by two types of Hallstatt ceramics (distribution by Kimmig 1979).

necessarily identical and can focus in different specialised central places. The concept of complex centres (Gringmuth-Dallmer 1996), which means that not all central places have to supply all central functions, implies polyhierarchies.

The term heterarchy refers to a structure without subordination and does not fit into the concept of central places. Sometimes this term is used to express, that there is not a single root of the hierarchy in a region. Then heterarchy means nothing but polyhierarchy.

For the reconstruction of polyhierarchies we can also use the concept of cultural territories. We simply have to analyse not the whole material in one analysis but use Typenspektren with special groups of material. These groups of material shall represent the different central functions. The results of our analysis (Fig. 8) indicate the existence of polyhierarchies.

As a result of these deliberations we have to distinguish several types of central places (Fig 9). The range lasts from isolated central places to polycentric places without complex centres. The parameters which make the differences are the degree of developing hierarchies and the correspondence of central functions. For each central place we have to test, which type it is in order to gain a good foundation for an interpretation.

Chronology

Up to now we used a static view and ignored chronology. The development in time is the next thing we have to analyse. The simplest method is to compare the maps and hierarchies for several time slices. Maybe we can distinguish different spatial models of centralisation. In some cases we can construct the genesis of territories. Given two phases and the knowledge of real borders and central sites we can analyse the ideal territories to get information about the genesis of territories. If the ancient ideal-borders and real borders do fit together but in the later phases there is a difference, we can suppose, that the later borders or location of central sites were not optimised. In this case it seems that the later territories are a fusion of the older territories because we otherwise would expect an optimisation of borders and central site (cp. Brun 2002).

System analysis

We have reconstructed settlement patterns and their underlying structures. But we do not know how it functions. This is the task of a system analysis. System analysis is focused on the relations between the

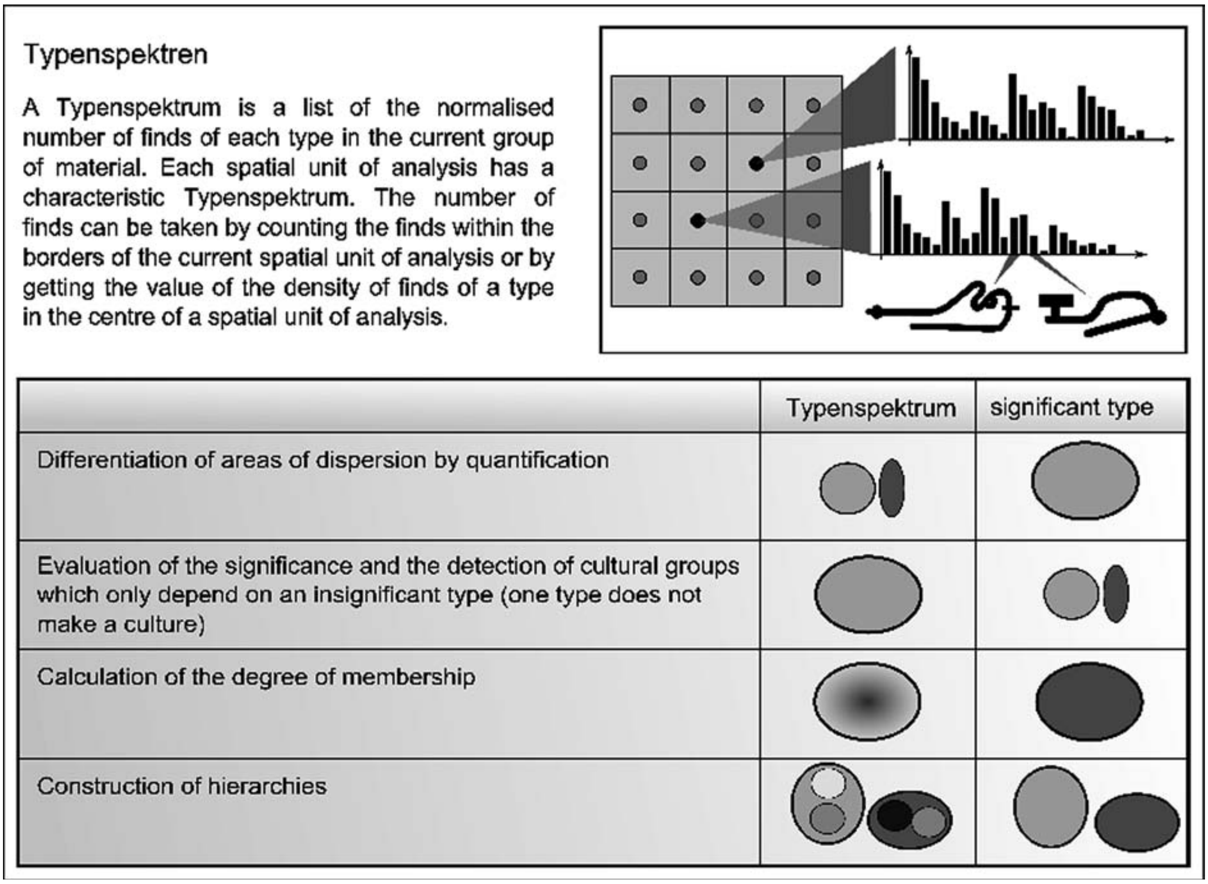

Fig. 6. Scheme of a 'Typenspektrum' and the advantages of 'Typenspektren'.

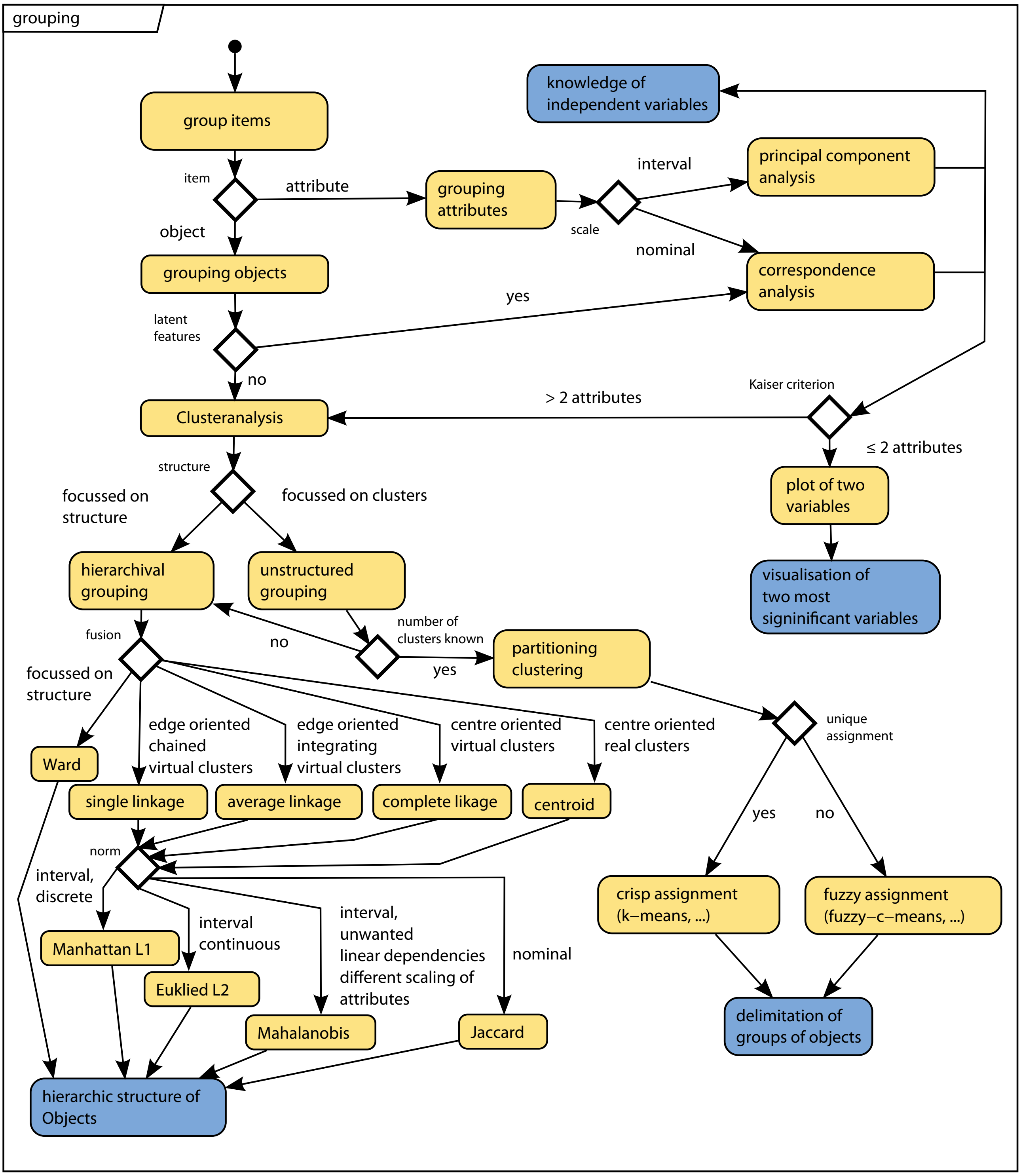

Fig. 7. Decision tree for finding the right method.

elements. Therefore, we need a special type of data to perform a system analysis: relational data. We have to distinguish two types of relational data. Weak relations are given, if two nodes are elements of the same network, but there is no flow between them. Strong relations are connected by a flow. The flow can be measured as a boolean, integer or decimal variable.

Generally we think of systems with linear dynamics (Bertalanffy 1948; Wiener 1948). They are sufficient for many economic problems. In recent years the analysis of complex systems was an advanced subject of research (Mainzer 1998). A complex system

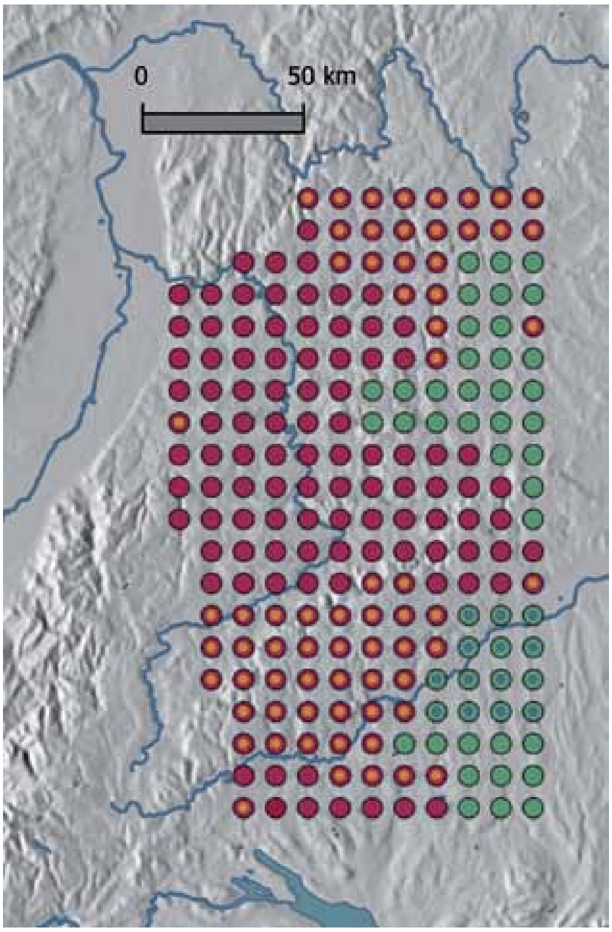

Fig. 8. Results of the cluster analysis on basis of cultural metrics from the project 'Siedlungshierarchien und kulturelle Räume'.

allows nonlinear dynamics and has some special features like emergence and butterfly effect. A complex system would be the right model for a cultural system.

Archaeological system analysis does generally not fulfil our requirements. I do not know of a complex archaeological system analysis. Only qualitative deliberations, as expressed by interaction diagrams (Stöllner 1996) are possible today. The other end of the spectrum of system analyses are network analyses (Brandes / Erlebach 2005; Scott 2000). They are comparatively simple, but nonetheless useful. Special types of finds can be used as relational data (Classen 2004). Theoretical models also can give us relational data by hand (Knappett / Evans / Rivers 2008).

We can define systems on many different scales. If we use the data from graves we gain a system with persons as nodes. If we use data from sites we gain settlement communities as nodes and so on. For analysing centrality, settlements are the right choice. If we are interested in central places in the sense of Christaller, we should start with central functions as relations. System analysis is not limited to Christaller's model.

As a consequence of this, the determination of centrality in a network (Brandes / Erlebach 2005; Freeman 1979) leads generally not to centrality in the sense of Christaller. Only if we define the system according to the model of Christaller can we gain information about centrality in the sense of central place theory.

For some years a shift from central place theory towards network theory can be observed in geography (Meijers 2007) and archaeology (Sindbæk

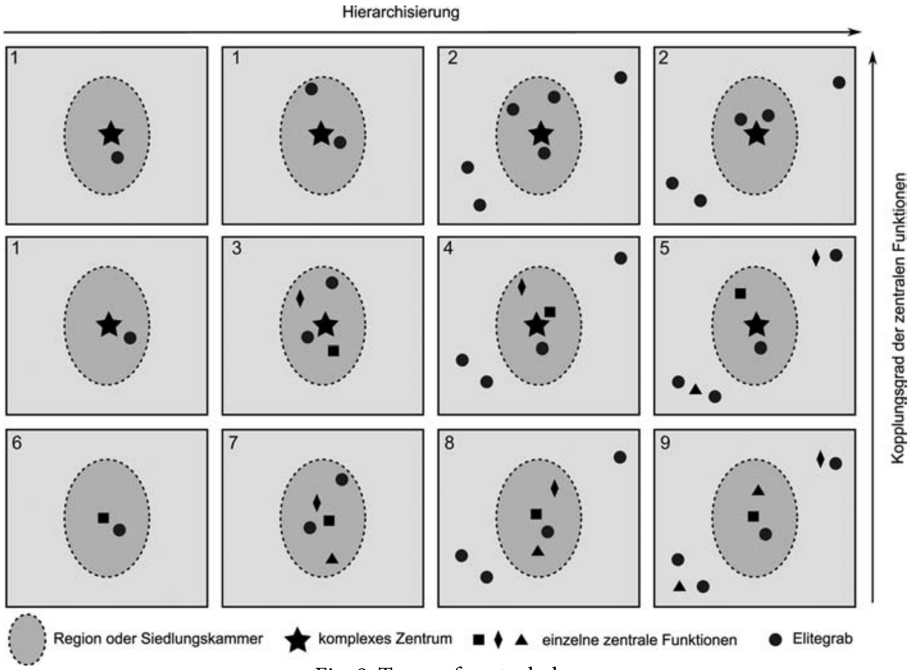

Fig. 9. Types of central places.

2007; MÜLLER in print a; MÜLLER in print b). It is suggested that network theory is a better framework to explain empirical data. In fact this is a simplification. A network model is a complementary model to analyse settlement patterns. Network models are focussed on other aspects and answer other questions. Whereas central place theory asks for the Hinterland of central sites, the network theory is interested in supraregional interconnectivity. Each site has a 'christaller centrality' and a 'network centrality'. A site is characterised by the value of each type of centrality and the ratio of both.

Systematisation of Central Place Research

The analysis of central places can be organized by five questions or tasks (Fig 10). None of the five tasks can substitute another. They are complementary concepts and not changing paradigms. The order of the tasks is the order of history of research and the order of data requirements. Some concepts refer to others, but they all are pieces in a mosaic where central place analysis is only a part. Especially network analysis is a complement to central place analysis. Together these concepts allow us to characterise the interaction profile of any site.

A systematization of methods is necessary for gaining a complete picture of the past. The removal of old methods from our toolbox is often not useful, since the methods may be complementing each other. We need a well ordered set of methods to get the right one for each problem.

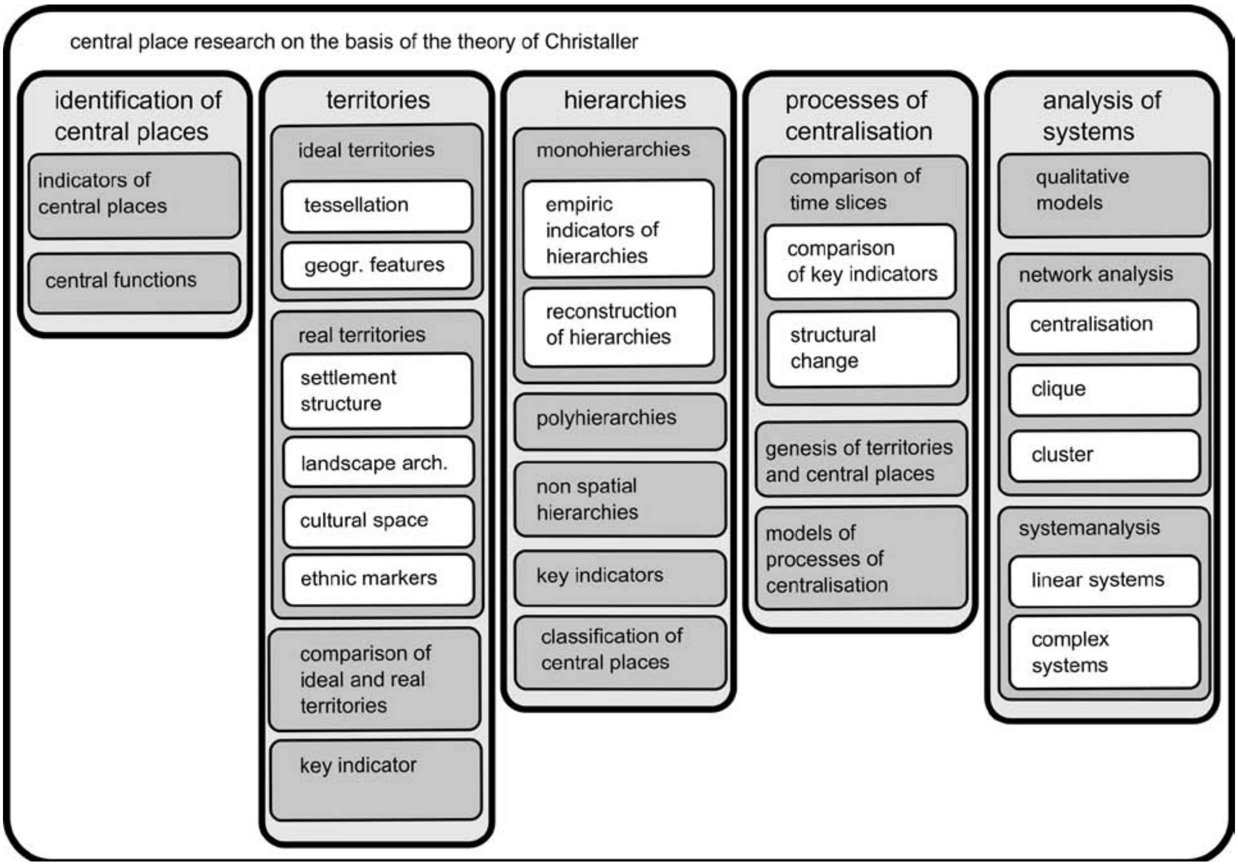

Fig. 10. Scheme of the analysis of central places on the basis of Christaller's theory.

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