2 Questions, limits, problems, aims

2.1 The origin of the question

Increasing population and space/inhabitant

After substantial migration from rural areas into the cities in the 19th century, the urbanised area of the Netherlands increased in the 20th century due to the explosive growth of the country's population (from 5 to 16 million) and then, even more importantly, to the increasing urban area required for each inhabitant. Since the Second World War, the average number of people living in a dwelling decreased from 5 to 2. The shortage of dwellings directly after the war resulted in an unprecedented level of building activity and the proliferation of rapidly built homogeneous suburbs in more spacious settings. The exploding number of cars demanded additional public space. The booming 1960s required even more urban space per inhabitant, in order to realise greenery and new facilities.

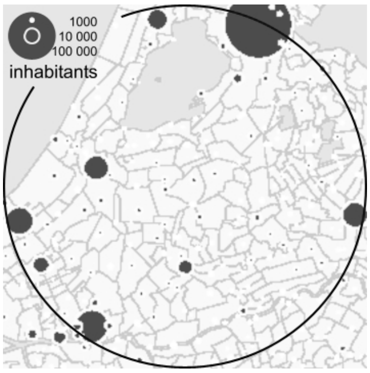

Fig. 11 A.D. 1800

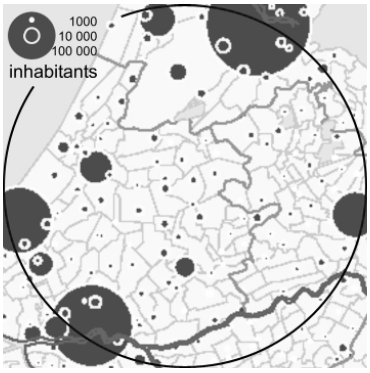

Fig. 12 A.D. 1900

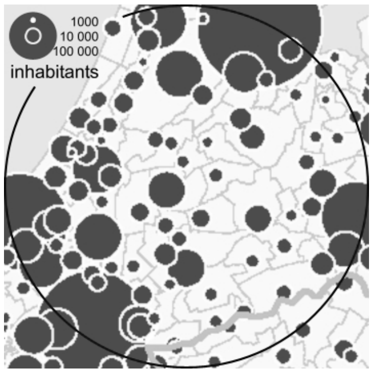

Fig. 13 A.D.2000

Population Randstad R=30km[a]

National Policy Documents on Spatial Planning

The First National Policy Document on Spatial Planning in the Netherlands was adopted in 1958.[a] This plan proposed to avoid additional sprawl by concentrating urbanisation in a ring R = 30km around an open Green Heart, in addition to outward de-concentration to new towns. Since that time, people began to demand additional diversity in residential environments, as well as more choice for themselves and for their children. The concept of 'environmental diversification' was therefore included in The Second National Policy Document on Spatial Planning, which was adopted in 1966.[b] This plan was represented in the form of a map comprising life-sized blocks (see *Fig. 14*).

[a] © Ekamper(2007)Bevolkingsatlas van Nederland(Den Haag)NIDI http://www.nidi.nl
[b] VROM(1966) *Tweede Nota Ruimtelijke Ordening* (Den Haag) Staatsuitgeverij http://www.canonro.nl/de_Canonro_nl/Leestafel/Nat__plannen/index.aspx

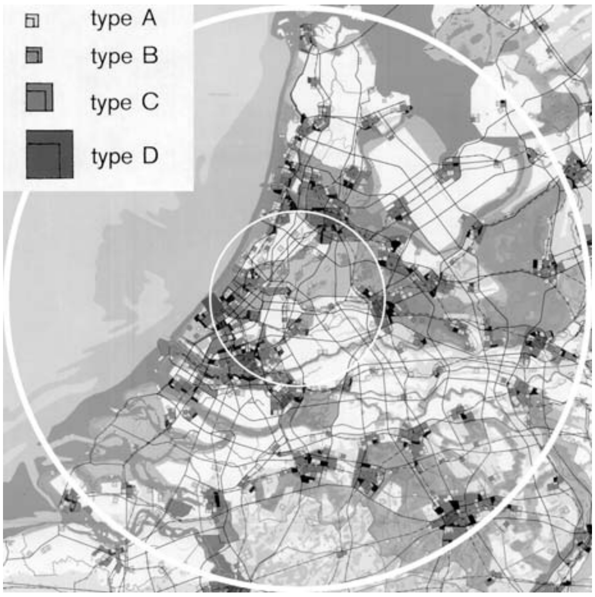

Fig. 14 Blocks map 1966 for 2000[c] R=100km

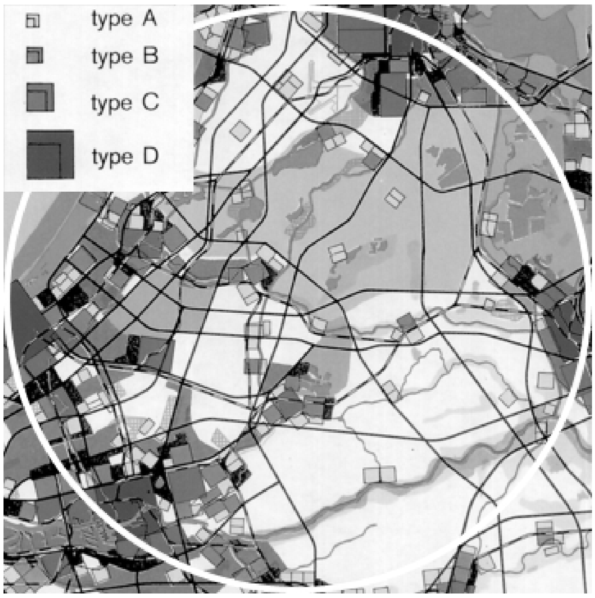

Fig. 15 Detail Fig. 14 radius R=30km[a]

Although this plan is now concerned a milestone in Dutch urban planning and regional design,[b] we no longer share its optimism with regard to the possibility of centralised spatial planning and design. The map was made by the design department of the Ministry of Spatial Planning, based on the expectation that it should provide housing for 20 million inhabitants by 2000. The Ministry's research department quickly deemed this projection too high. The research department then took the initiative for developing a third national plan[c], but these efforts eventually failed due to an overload of research reports and a lack of a clear concept. The fourth national plan (VINEX) once again proposed concentration in 'compact cities'.[d] This plan resulted in a multitude of 'VINEX districts', which soon drew criticism for their excessively diverse, chaotic appearance and their failure to realise sufficient density to avoid sprawl to any substantial degree. The last (fifth) national plan accepted more sprawl, but it was never adopted.[e] The Ministry of Spatial Planning was assumed into the Ministry of Infrastructure and the Environment, assigning additional responsibility for spatial development to the regional and local authorities.

Design realised with a different content

If you you compare *Fig. 12* with *Fig. 13*, then you should admit that the design of *Fig. 14* largely covers the current reality. The over-estimated population has been compensated by an unforeseen increase in urban land use per inhabitant, thus generating a similar picture. Upon closer examination, however, the intention of environmental diversification is less recognisable. For areas in which prosperity is still expected to increase, however, diversification is more pressing than ever. Without sufficient diversity from which to choose, the increasing prosperity becomes prosperity without choice. In the 1960s, the younger 'alternative' people were looking for 'alternatives'. They were populating the Ministry during my residency to study environmental diversification.

The concept of Environmental diversification

'Environmental diversification' originally referred to the development of residential areas with increasing diversity in terms of density, size and level of facilities (Environments A, B, C and

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[a] VROM(1966) *Tweede Nota Ruimtelijke Ordening* (Den Haag) Staatsuitgeverij
[b] http://www.canonro.nl
[c] VROM(1977) *Derde Nota Ruimtelijke Ordening. Verstedelijkingsnota* (The Hague)RPD
[d] VROM(1992) *Vierde nota over de ruimtelijke ordening Extra* (Den Haag) RijksPlanologische Dienst
[e] VROM(2001) *Ruimte maken, Ruimte delen, Vijfde nota over de Ruimtelijke Ordening 2000/2020* (Den Haag)Rijksplanologische Dienst

D; see *Fig. 15*). Its meaning, however, was soon extended into other levels of scale and other categories. It was concerned applicable to 'the entire range of transitions in the urban and rural area'.[a] During the development of the third national plan,[b] it appeared as the second basic aim of national spatial planning: 'The stimulation of spatial and ecological conditions in order to guarantee as much diversity, coherence and sustainability of the physical environment as possible'. In this context, the term 'sustainability' appeared a decade before Brundtland[c] advocated it (with a global impact) in order to preserve freedom of choice for future generations. In Brundtland's case, however, the concept of sustainability was directly connected to environmental diversity.

Diversity as a condition for choice

Instead of aspiring to achieve one 'best' solution for spatial planning and design everywhere, environmental diversity was recognised as a necessary condition for choice. In addition to offering choice for future generations, it offers choices to the present inhabitants (Environments A, B, C and D), with their different stages in the life cycle, different income groups and different life styles.[d] Instead of prescribing a single 'best' quality, this national strategy stimulated a variety of qualities. It also offered choices for lower levels of administration. It allowed for differences between regions, municipalities or neighbourhoods.
The documents preceding the third national plan elaborated the main aim into partial aims. The concept of environmental diversification was explicitly declared applicable at four different levels of scale: national, provincial, urban regional and local. The natural environment was finally mentioned as an area of application: the stimulation of diversity in ecological systems. When concentrating the urban built-up area, the plan called for open buffer zones between urban zones in order to realise a kind of environmental diversification with nature close to home.

Failing control

In the years that followed, the emphasis on environmental diversification faded. The intended strategy failed due to a lack of political instruments. Control systems are uniform by nature; they tend to generalise instead of differentiating. If this is the case, you would do better to avoid control systems and leave the diversification to private initiatives. I have my doubts, however, given that diversity at the lowest level of scale may cause homogeneity at the other levels. Moreover, globalisation has increased the power of corporations to a level that matches that of governments. You can recognise them in any shopping centre in any neighbourhood, anywhere in the world. You can no longer escape this homogeneity through travel.
The subject of this treatise is thus not aimed at finding administrative instruments for environmental diversification. The concept itself must first be clarified.

Urban and rural environments

The origin of the question was based on the range of environments between urban and rural areas. It has now become popular, however, to suppose that there is no longer any distinction between urban and rural areas. Nowadays, any rural area in the Netherlands has been urbanised. The term 'urbanised', however, depends upon the level of scale and the associated variables that you take into account. To say that the entire world is urbanised is to strip the word 'urbanisation' of all meaning. There are differences in urbanisation, regardless of whether any purely natural zero point exists for that variable.

Many variables involved

In most cases, towns of different sizes have differing levels of amenities, a different

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[a] RPD(1971)*Publicatie 2*(The Hague)RijksPlanologische Dienst
[b] VROM(1974) *Nota van Wijzigen op de Oriënteringsnota* ('s-Gravenhage) Staatsuitgeverij
[c] Brundtland(1987) *Our Common Future* (New York)UN
[d] Michelson(1970) *Man and his urban environment: a sociological approach* (Menlo Park, California) Addison-Wesley Publishing Company, Inc. Philippines

relationship to the surrounding countryside and a different relationship to other towns. They consequently offer different living environments and attract different ages, income groups and life styles. Since 1967, the Dutch national strategy for providing such different living conditions has been known as 'environmental diversification'. This strategy was soon applied at other levels of scale and spatial categories as well. Its study was intended to clarify the meanings of the term and its consequences.

Variables of different order

The *content* of the relationship between urban and rural areas may be determined by variables of the first order (e.g. the range from culture to nature, the amount of built and vacant surface, high and low densities of inhabitants, employees and facilities). Any of these variables may produce different patterns applied at different levels of scale. *Form* may be expressed in values of dispersion between accumulation and spread at different levels of scale, as the term 'bundled de-concentration' apparently indicates. Bundled de-concentration was part of the above-mentioned strategy of 'environmental diversification'. It was intended to concentrate within a radius of 30km, while de-concentrating within a radius of 10km. *Structure* arranges different values of isolation and accessibility (a third-order variable) across larger and smaller towns and their inhabitants. These different kinds of isolation or connectedness attract different *Functions* (fourth order) are attracted by within that structural diversification. This relationship is not deterministic or causal, but conditional. Although agriculture in the city and industry in the country are still possible, they are limited. *Intentions* (fifth order) may change the distinction between town and country, but they are motivated by functions and conditioned by the existing functional diversification.

Variables applicable inside and outside urban areas

This example of differences between urban and rural environments clarifies how the parts of this study can be applied to the distinction between town and country, within the desired of applicability at any distinction within or outside the city. Most of the examples provided in this study stem from urban areas. This is not because the developed terminology would be not applicable to rural areas or intermediate areas. It is because of the complexity of urban areas, in which the full extent of environmental diversification may be shown.

More contrasting values by human impact

The distinction between diversification of content, form, structure, function and intention in this study is inspired by the fields of biology and ecology. Its application to agricultural and natural areas is even more obvious than its application to urban areas. A natural landscape provides an even better example of how environmental variables may vary over a characteristic distance, with fewer contrasting values maintained by fewer sharp separations. Gradual transitions show more diversity of plants and animals than do sharp boundaries.

Ecology

For ecology, the relevance of this study with regard to the concept of 'content' may lie in the suggestion to pay more attention to the scale of environmental variables and to their dispersion in space, their structure and their function. Scale articulation might simplify and deepen the analysis of ecological systems. It might even disclose new areas for ecological research. The natural landscape also comprises many variables (wet/dry, acid/base, flat/hilly), as well as the associated phenomena of accumulation and spread of their values, including all forms and shapes in between. This applies to the presence of different species as well as to the values of environmental variables. The form of the landscape is determined by different dispersions of different elements. In addition to *form*, a natural landscape also reveals an ecological *structure* –i a set of separations and connections, barriers and rivers, gradients of sensoric or motoric accessibility. These separations and connections (selectors) have different meanings for different plants and animals. They are therefore selective in different ways for different organisms (e.g. insects, mammals or birds). They consequently

differentiate between closed and open ecological communities of species. The gradients between open and closed areas may be represented as environmental polarities to be arranged in a way that is characteristic of each landscape.
Finally, the natural landscape has a diversity of functions for any accidental organism, including humans. Conversely, any organism has a different function for the landscape. In this case as well, the concept of 'function' has two opposite meanings: the outward function of parts for the whole and the inward function of the whole for its parts. As in this anthropocentric study, it is thus possible to distinguish different kinds of function.

Urban landscapes

The distinction between content, form, structure, function and even intention can thus be applied to both cultural and natural landscapes. In this study, however, it is elaborated primarily for urban landscapes. With regard to the intention of environmental diversification, humans and human society are central in this study. The natural landscape is thus addressed only within the context of its potential functions for humans and society. Because the study concerns design, it is primarily anthropocentric.

Subsequent questions

The multitude of levels and categories to which the concept of environmental diversification can be applied to urban and rural environments raises several questions:

a. Are there other conceivable meanings for the term 'environmental diversification'? Are there other fields of application possible? How are they connected to each other?
b. Which environmental variables can help to provide a more scientific grasp of the phenomenon? Which values do these variables take in reality, and which other values might still be possible? How are they bound to levels of scale? What is their relationship at and between various levels of scale? How may their values be combined into new types of environment that could be applied in design?
c. Could environmental diversification at one level of scale obstruct diversification at other levels? For example, could national diversification cause regional homogeneity? To what extent is it thus possible to extrapolate conclusions at one level of scale to other levels? For example, if you decide that residential, industrial, recreational and traffic environments interfere with each other and that they must be separated, is the municipal level the appropriate level at which to realise this kind of environmental diversification? Could this be called scale falsification? If you aim to achieve freedom of choice for the users, is it necessary to apply the diversification of environments (represented in the legend units of your drawing) at the appropriate level of scale? When does it become falsification?
d. Can other aims from spatial planning and design be reduced to environmental diversification? For example, is the concept of bundled de-concentration a kind of environmental diversification? How are accumulation, spread and similar phenomena related to environmental diversification?

Questions such as these require a fundamental inquiry into the concept of environmental diversification in all of its manifestations. It requires locating them in relation to each other, determining whether they tolerate each other and investigating whether mutual reinforcement or obstruction could be context-sensitive. In formulating a study that could answer this kind of questions, my primary task is to define the concept of environmental diversification in more detail. I can attempt to create an overview of the entire conceivable field of study in order to select the appropriate limitations for a statement of the aims and problems.

2.2 Limits of definition

Defining diversity and environment

In this study, environmental diversification refers to the development of additional diversity in the environments of people, or to the results of such development.
The terms 'diversity' and 'environment' thus require closer investigation.

Diversity

First, we should distinguish at least two kinds of diversity: morphological and functional. This distinction is necessary, as they do not always go together. For example, the proper maintenance of monuments in a mediaeval inner city may retain its morphological diversity, although its functional diversity could decrease if only offices and shops remain. Conversely, an increase in different activities and ways of use can create a homogeneous appearance within the multi-functional environment. The connection between form and function is a classical question in design theory ('form follows function'). This study demonstrates that a third kind of diversity is needed in order to solve this question: structural diversification. Let us leave this and other the distinctions aside for a moment. Functional diversification assumes a diversity of collectively accepted use. Morphological diversity assumes a locally different composition of variables operational in each environment (i.e. content, as in material or colour) and the different dispersion of their values in space (i.e. form). To be precise, you should distinguish this into a diversity of content and form. For the time being, however, it is sufficient to be aware that there are different orders of diversity.

Environment

The term 'environment' deserves elaboration as well, given that it introduces an unlimited factor to the definition of environmental diversification, even if we limit our attention to the environments of people. 'The environments of people' can refer to rooms, but also to towns. You may therefore encounter very different meanings when speaking about environmental diversification. Let us start with the usual definition of 'environment':

> the totality of factors from the surroundings of organisms that have an impact on life and living of these organisms.

This definition distinguishes 'life and living', as the 'impact' should not refer only to mere survival, but also to the different possible ways of living that are conditioned by an environment. You can immediately replace the vague term 'from the surroundings' with 'within a given radius'. The definition then assumes a given radius before it becomes operational. In this study, therefore, the concept of 'factors' is used to refer to 'variables and the variations in their values' (within a given radius). This places diversity in a central position within the definition, and it provides a limitation to spatial diversity through the given radius. It is then possible to replace the term 'organisms' with the term 'people'. In many respects, the argument may remain relevant for other organisms. Through this substitution, however, the term 'have an impact' should be replaced by '*can* have an impact'. After all, humans are able to change their environment by design and make use of variables that have previously had no impact (e.g. the presence of peat, coal, petrol or raw materials). This broadens the definition, although the other amendments have narrowed them.
The application of these substitutions yields the following definition of environment:

> the totality of spatial variables and their values, varying in a given radius around people that can have an impact on their life and living.

Environmental diversification

The 'totality' can differ from place to place within the environment, thus reflecting a diversity of places within that radius. in its turn, diversity can develop ('diversify'), thus covering the core of the inquiry: environmental *diversification*.

However,

> if we will study environmental diversification at any different scale separately,
> if we select variables according to their relevant 'wavelength' at each scale,
> if we neglect other variables that may be operational at other levels of scale,

a difficult question remains.

For example, the climate and soil variables in our environment do have a different operational level of scale in space and time. The variation of the climate is a matter of hundreds of kilometres and millennia, while the diversity of the soil is a question of metres and centuries. The diversification of the soil is clearly connected to the history of climate. At different locations, the variables with a larger reach will cause other contexts for environmental diversification at the local level. In a different context, the impact of the chosen variables may become different. How can we derive any conclusion from such an argument that may be valid in locations other than those we took into account?

Possible diversification

The answer may be embarrassing; it is not the primary objective of this study. The primary objective is not to conduct empirical *research* but to sustain *design* and *technique*. Although it should be *understandable* to empirical researchers, I do not wish to make *predictions*; I would like to explore *possibilities*. I restrict my attention to variables that can be influenced by design, and the reach of design, execution and use in space is limited. I do not wish to explain the history and the inconceivable diversity of our environment by using generalisations that *reduce* it. I want to find means to preserve and to *produce* it.

Scale articulation

There may be an objection that is typical for designers: 'in designing you never stay at one level of scale; any designer should design through the scales!' Although I agree, in order to integrate them you must know what every distinguished level of scale means, what it does or what its possibilities are. Another question concerns how far we would like to go distinguishing levels of scale. Do we hope to design every molecule of the building? Will we take the whole universe into account when designing a building? The variables that may describe the 'content' of the environment do not vary at the same scale, in the same rhythm or in the same way. Their impact may be different at different levels of scale – even in an opposite manner. Heterogeneity at one level of scale becomes a homogeneous mixture at another level of scale. I referred to this phenomenon as a 'scale paradox' (see *Fig. 7* on page 21). It may result in the use of variables and their values (legend units) at the wrong level of scale. For example, recall the CIAM division in urban functions, as presented on page 12. If you use legend units from a different level scale, you may think that it is 'designing through the scales', but I would refer to it as scale falsification. From the perspective of environmental diversification, scale articulation is a crucial stage. It enables to obtain insight into the mutual relationships between different levels of scale. An important simplification and deepening of the analysis can be reached by first binding it strictly to spatial levels of scale and subsequently contrasting those stemming from different levels with each other in order to analyse the combinations. To do so, however, would require a combinatory explosion of studies that exceeds the scope of a study of this type.

Scale bound disciplines

I also considered binding the analysis to levels of scales in time. By doing so, however, I did not succeed in simplifying the analysis enough to maintain an overview. Moreover, scale articulation in space is more obvious in a study concerning spatial planning and design. The scale-articulated analysis of diversity may thus temporarily neglect variables that essentially belong to other responsibilities of our spatial organisation.

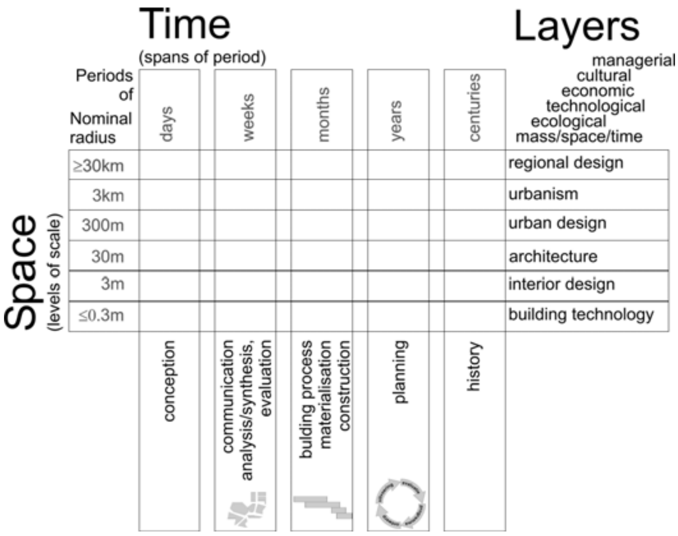

Fig. 16 Disciplines bounded in time and space

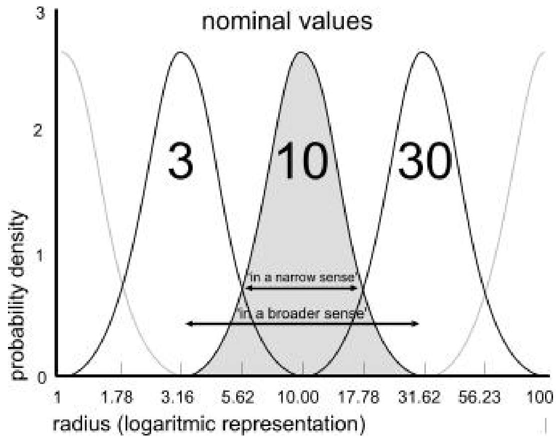

Fig. 17 Defining Nominal radius R

Scale	Nominal radius R	Nominal surface	10x10 cm Scale 1:	G-scale Hagget	Urban types (1966)	Potential urban form	Potential urban function
Micro	1m	3m^2	20	14	a	spot	grip space
	3	30	60	13	b	place	room
	10	300	200	12	c	parcel	building
	30	3 000	600	11	d	block	building group
	100	30 000	2 000	10	e	allotment	ensemble
	300	300 000	6 000	9	A		neighbourhood
Macro	1km	3km^2	20 000	8	B		district
	3	30	60 000	7	C	built-up	town
	10	300	200 000	6	D		conurbation
	30	3 000	600 000	5	E		urban region
	100	30 000	2 000 000	4	F		region
	300	300 000	6 000 000	3	G		land

Fig. 18 Twelve levels of scale

The levels of scale studied

In principle, therefore, I distinguish twelve different levels of scale. These levels need not have a functional meaning. Nevertheless, they do assign twelve different meanings to the concept of 'environment' (and thus to the concepts of environmental diversity and diversification). The twelve levels of scale are represented in *Fig. 18* by a number of characteristic numbers, codes and terms that are intended merely as indications or orientations. The semi-logarithmic series can be extended, if required. The nominal radius serves as a name for the level of scale of the intended environment. Its numerical value should be interpreted 'elastically', as a variable between the preceding and the following number in the series. For example, if I refer to a nominal measure by 'R=100m', I mean an environment with a radius between 30m and 300m (a diameter between 60m and 600m) or a surface between 0.3ha and 30ha (frame). In formal terms, '100m' is the average of a logarithmic probability distribution, with 30m and 300m as extremes. If you would like to make a 10x10cm picture or a map of the intended environment, the smallest appropriate proportional scales you could use are summarised. The average 'R=100m' can thus be depicted at 1:2000. This raises the question of resolution: What is the *smallest* subject that you take into account? If you take the elastic radius r of the largest circle or globe fitting in the smallest subject concerned as its nominal size (grain), the resolution is defined as r/R. In this study, this proportion between grain r and frame R will be 1%, the resolution of a normal drawing. A similar concept for the series of scales chosen here is the 'G scale', as introduced by Hagget (1965)[a]. It relates any scale to the total surface of the Earth (G-scale=0). The values presented here have been rounded off.

Agreement with usual urban categories

According to Hagget, this semi-logarithmic series is morphologically and functionally indifferent, at least in theory. These average measures, however, correspond surprisingly closely to the usual morphological and functional names presented in the last two columns. For example, if you draw circles around the surface of neighbourhoods, districts, towns and conurbations on the topographical map of the Netherlands, you will recognise the set of nominal radiuses R= {0.3, 1, 3, 10km}. The codes for environments in the previous column correspond to the Types A, B, C and D that were mentioned as a legend in the 1966 National Plan shown in *Fig. 15*. The series corresponds relatively well to the more functionally oriented series developed by Doxiadis[b], although this series has different intervals. These names have yet to be taken as informal examples of well-known forms and functions of similar size.

Every scale has its own legend units

The levels presented in *Fig. 18* divide the general concepts of environment, environmental diversity and diversification into twelve more specific meanings and contents. Their content can be represented by environmental variables, sorted according to the scale of their working. In other words, we can distinguish a room, a house, a property, an ensemble, a neighbourhood, a district, a town, a conurbation or an urban region with different variables or legend units, and consequently with the means of design. Some of these variables may have a range that is broader than that of just one of the distinguished levels. The design means may thus continue to differ. For example, if we take the variable of 'light', we can differentiate between light and dark in a room, a house, a larger building and its surroundings, perhaps in a neighbourhood, but less so in a district, town or other entity. At the highest levels of scale, however, it once again becomes responsible for the diversification of climate zones. Any environmental variable may thus be more applicable for design at some levels of scale than at others. Environmental diversification changes according to the level of scale through differences in the composition of variables.

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[a] Haggett (1965,1977) *Locational analysis in human geography* (London) Arnold
[b] Doxiadis(1968) *Ekistiks. An introduction to the Science of Human Settlements* (London) Hutchinson
Doxiadis(1970) *Ekistics, the Science of Human Settlements* (Science)1023 170 3956 p 393-404

2.3 Limits of scientific context

Questions

A comprehensive study of environmental diversification requires eight areas of study:

1 Related concepts of 'environmental diversification' in other disciplines
2 Exploring theories that may play a role in environmental diversification
3 The historical development of environmental diversification
4 Processes of levelling down the diversity of human environments
5 The desirability of environmental diversification
6 Environmental diversification in existing spatial plans and designs, study of legends
7 The variables of environmental diversification, their spatial appearance
8 Applied studies of environmental diversification

Limiting the question

This thesis is largely restricted to the seventh point (i.e. the variables of environmental diversification and their spatial appearance). In this case, 'appearance' includes the not necessarily visible separation and connection of the values of these variables. The other areas are raised only if they are relevant from this point of view. They are the context within which the subject is limited further. The following paragraphs provide a brief elaboration of this context, in order to clarify what is *not* studied in depth.

1 Not a study of environmental diversification in other disciplines

The concept of 'environmental diversification' has many relationships to well-known concepts in other disciplines (e.g. difference, heterogeneity, variation, variety, variables, change, alternation, specialisation, integration, dispersion and their opposites). Their connection to the environment opens up a connection to history, biology, environmental sciences and other fields. It also connects to such concepts as form, structure, function and intention, as used in many other disciplines and in daily parlance with their foundations in logic (modal or fuzzy) and philosophy[a]. These connections should be explored. Given that many disciplines are involved, however, we first need a trans-disciplinary vocabulary and method with which to explore these concepts systematically.

2 Not an overview of *theories* related to environmental diversification

Although you could develop an abstract system of logically related definitions in order to clarify the concept of environmental diversification, you could also seek a connection with existing theoretical conceptions from other sciences and the humanities. For example, the concept of inequality can be approached statistically.[b] In physics (particularly thermodynamics), many points of contact are available on this basis. In biology, 'diversification' or 'differentiation' is a key concept for understanding growth and form,[c] particularly in embryology and ecology, where it refers to sequences of succession.[d] Sociology has its notorious philosophers of diversification and specialisation[e], as well as the 'fathers of sociology'[f], who started their careers with 'diversification'. Even the functionalists[g] could not avoid the concept. Since its establishment, economics has been involved with the division of labour, specialisation and economic diversification as a condition for trade.[h]

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[a] Deleuze, G. (1994) *Difference and Repetition* (New York) Columbia University Press
b Lisman(1976)*Ongelijk, ongelijkmatig, onregelmatig en ongeregeld*(Economisch Statistische Berichten)1122 p907-914
c Arcy Thomson(1961) *On growth and form.* (Cambridge UK) Cambridge University Press
d Leeuwen(1966) *A Relation Theoretical Approach to Pattern and Process in Vegetation* (Wentia) **15 p**25-46
e Spencer(1897) *The principles of sociology* (New York 1929)
f Simmel(1890) *Ueber soziale Differenzierung, Soziologische und Psychologische Untersuchuchungen* (Leipzig)
Durkheim(1893) *De la division du travail social* (Paris 1967) Presses Universitaires de France
g Malinowski(1944) *A scientific Theory of Culture and other essays* (Oxford 1964) Oxford University Press
Radcliffe-Brown(1952) *Structure and function in primitive societies* (London)
Parsons(1966) *Societies : evolutionary and comparative perspectives* (Englewood Cliffs, N.J.) Prentice-Hall
Luhmann(1974) *Soziologische Aufklärung* (Opladen)
h Smith(1776) *An inquiry into the nature and causes of the wealth of nations* (London 1929)

3 Not a historical study of environmental diversification

You could clarify the meaning of environmental diversification from the perspective of evolution and history. In this case, however, it would be necessary to begin with the anthropological genesis by which humans developed limbs, a receptive system and the capacity to predict sequences.[a] You should then conclude from archaeological and ethnographic data how human settlements and houses have developed in interaction with the surrounding nature – how neolithic, industrial and other technological revolutions have had their impact. Finally, you would have to study the technical, political and economic history of humankind in order to get insight into the impact of class struggle, concepts of ownership, customary and written law and other factors on the diversity of environments.

4 Not a study of processes of levelling down

If you are worried about these developments, you should study the differentiating and levelling tendencies existing within an industrial-commercial society that you would probably wish to counteract. In addition to being historical in tone, such a study would have a technical, legislative and political character. You should make an inventory of the kinds of freedom that societies have gained and lost. The study should contain the influence of the explosive development of the money economy, mobility, communication, the use of materials, energy and information, their global exchange and their consequences in terms of the separation and combination of functions.

5 A limited attention for the desirability of environmental diversification

The motives for environmental diversification in and of itself constitute a vast area of study. They must be separated into motives that centre on the human as an endpoint of evolution and those that do not. The first group of motives takes ecological, economic, medical, psychological and philosophical considerations as a starting point, in order to demonstrate their utility for humans. The second system of motives proceeds largely from the natural development of 'ecosystem Earth'. It has to do with ethical obligations to a process of diversification and temporary stabilisation that caused and safeguard your very existence.

6 Not a study of existing spatial plans and designs, no study of legends

If your objective is to influence the diversity of environments, you should study the contemporary practice of policy, planning and design at different levels of scale, the variables that they may influence and the instruments that they use for this purpose. You should investigate which instruments and levels of scale are most effective, and whether other instruments and variables are still available. For example, you could study the usual legends of sector plans for agriculture, traffic, water management, energy supply, master-plans, as well as the more detailed integrated plans for towns, districts or neighbourhoods or other entities. You should study their interference – their mutual impact in order to gain an impression of their effects on the actual level of environmental diversification.

7 A study of design means

In addition to studying the concept of environmental diversification in relation to other disciplines, with regard to its logical structure, or as an historical, threatened, desired or consciously influenced phenomenon, you could study environmental diversification as a working of scale-sensitive environmental variables. You would then need to study the dispersion of the values of these variables in space, having locally different relationships to each other and different functions for humans. This kind of study would provide an active view of *possibilities*. It establishes a balance between science (or the humanities) and design (or technology). It establishes a balance between reflection and application, between past and future. It provides the greatest chance of relevance for policy and design, while remaining understandable to – and applicable in – science and the humanities.

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a Harrison;Weiner;Tanner;Barnicot(1964) *Human Biology* (Oxford) The Clarendon Press

8 A limited study of applications

Finally, you could study environmental diversification through application. The question of environmental diversification plays a role in any question of spatial layout, whether hidden or explicit. It is important to determine this role and to determine what is possible and what is not. This type of study requires insight into the possibilities demonstrated by empirical research, promised by theory or assumed by imagination. It requires the capacity to make more differences than you could ever have imagined before now.

Limits of context

It may be clear that this study cannot cover all of these areas. I thus restrict my analysis to the part that promises a key position in the communication between science, technology and policy: Point 7. Even this restriction, however, opens up a vast field of study. It requires further limitation before I can formulate its aims and the problems that it attempts to solve. It requires the further limitation of ‘environment’, ‘scale’ and ‘diversification’ than was provided in Section 2.2. Exploring the limits of what *can* be done at all, unveils considerable knowledge about what *has* been done.

2.4 Limits of 'environment'

Combining your reduced impressions

Your environment provides you with an overwhelming flood of data that enters through all your senses – vision, hearing, smelling, tasting, touching, motion and perhaps others. You cannot be fully aware of all of the information you receive. An initial selection is already made for you by *distance*. The resolution of your senses reduces the information about remote objects as a background, which is less recognisable but more stable than nearby objects are when you move (parallax).

Memory

A second selection is made by *time*, through a memory that fades immediately and stores selectively. Actual impressions cover or refresh the selected memories of previous impressions as an ash rain over a landscape with bare peaks, valleys of mud and a layered soil. The steady peaks erode and the valleys are covered, but much is removed by rivers of oblivion. Old memories may be uncovered by the wind or through conscious digging. Most of these memories are merely fragments, however, sometimes combined in strange sequences and distorted objects in dreams or fantasies, or consciously reconstructed and properly dated. Underneath this landscape, however, sudden dark, unconscious movements or eruptions can lift some memories and depress others.

Sequence

This is the point at which the analogy to a landscape ends, because if there is no *change* of impressions, you will become bored and lose attention. If the impressions are already present, it is no longer necessary to store them anymore. *Change* arouses your attention. At some point, you start to select the changes themselves, storing them for comparison as patterns of sequence. That is a typically human activity.[a] You may refer to some elements of these sequences as cause and effect. I refer to the data combined with such assumed relations in time as 'experience'. This raises the question of how we learn to perceive our environment successively, assisted by increasing experience.

Imagination

The answer to this question should clarify how you may overcome the earlier reduction of impressions by distance. You have learned to imagine remote and larger environments than those you actually can observe. They are stored in categories other than those you distinguished within some direct environment at a younger age. The maps in an atlas show legend units that you cannot immediately observe in that environment.

Innocent perception

A study of child perception suggests that you have observed your first environment as an uncoordinated mixture of impressions. Your impressions of temperature, smell, taste, touch and noise changed dramatically at the time of your birth. Once you opened your eyes for the first time, a visual experience should have been added as a changing coloured mosaic, a *tableau mouvant*.[b] In the years that followed, this chaotic world gradually became understandable. What you can see is primarily flat, because your retina is flat, and the flat impression of your second eye is only slightly different. It is necessary to *construct* a third dimension by combining vision with other simultaneous impressions. Awareness of depth and the interpretation of stereoscopic view were probably initiated by new impressions of movement, combined with vision and touch. The beginning of 3D awareness may emerge as soon as some of the observed patterns can be touched and others cannot.

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[a] Harrison;Weiner;Tanner;Barnicot(1964) *Human Biology* (Oxford) The Clarendon Press
[b] Piaget, J.; Inhelder, B. (1947) *La representation de l'espace chez l'enfant* (Paris) Presses universitaire de France

Pattern recognition

In the meantime, some pattern recognition may have been established based on the *difference* and *constancy* of objects. Identifying an object, determining its ‘identity’ is to observe ‘repeatedly the same’ (idem tidem, the etymology of ‘identity’). Recent studies of pattern recognition conducted with computers[a] indicate that differences of patterns in space must be recognised first (edge-construction) before their constancy (equality in time) can be concluded efficiently. In contrast, human pattern recognition is assisted by simultaneous information from our own movement and sense of touch. The miraculous synaesthetic synthesis of these completely different impressions of view, movement and touch into an awareness of separate objects in space must be learned. It is not self-evident that babies will recognise their mothers at a distance as being the same as their scope-filling mothers when they are close by (object constancy).

Identifying objects

It is natural to suppose that, for the first stage of pattern recognition, clearly different (coloured) and bounded objects in the direct environment (R=1m, grip-space) can help a child to distinguish or to identify objects (a primary condition or requirement for developing self-awareness, discovering your own boundaries and identity). The simple, clearly coloured and bounded drawings of Dick Bruna and or traffic signs illustrate this requirement for children and for rapidly moving or distracted adults. Complete homogeneity in the early environment has been suspected even as a cause of death for babies in an orphanage.[b] They died of boredom. The variables that generate the synaesthetically necessary diversity (e.g. colour, contour, movability, variations of hard and soft) are not always recognised by designers as means of design (i.e. as possible legend units in their drawings).

The radius of action

The size of an environment in which you can distinguish objects increases with age. Suppose that the environments you explored when you were 1, 3, 5, 7, 9 or 11 years old had a radius of approximately 1, 3, 10, 30, 100 or 300m, respectively. Which environmental variables at each of these levels may be important in order to become familiar with your environment, and which should play a role in designing them? This is not only a question of content or morphological (e.g. visual) diversity; it also involves structural and functional potential. The fundamental question of which kinds of difference are relevant for design has yet to be answered. Which variables can be varied at different levels of scale to provide sufficient opportunities for different people at different ages and with different lifestyles?

years old	**0**	**1**	**3**	**5**	**7**	**9**	**11**	**13**	
m Radius of frame	**1**	**3**	**10**	**30**	**100**	**300**	**1000**	**3000**	
Differences to experience:									**learning:**
hard|soft	x								danger
movable|non-movable	x								operational abilities
colour	x								recognition
windows|doors		x							orientation
light|dark		x							imagination
shelter|corners		x							to escape movements
function|time		x							every time its own place
visibility		x							hide-and-seek
accessibility			x						rules
control			x						other people
noise			x						context

[a] Pekalska (2005) Dissimilarity representations in pattern recognition (Delft) TUDthesis
[b] Spitz, R.A. (1945) Hospitalism: An inquiry into the genesis of psychiatric conditions in early childhood **IN** Psychoanalytic Study of the Child. Vol 1 (New York) International Universities Press p53-74

years old	**0**	**1**	**3**	**5**	**7**	**9**	**11**	**13**	
m Radius of frame	**1**	**3**	**10**	**30**	**100**	**300**	**1000**	**3000**	
Differences to experience:									**learning:**
temperature			x						kinds of clothes
wetness				x					hygiene
ceiling|shelter				x					in-betweens to hesitate
plantation				x					nature
sun				x					nature
formal-informal				x					different behaviour
recognition|suprise				x					initiative
run|compete					x				ambition
watch, learn					x				to learn
possibility to buy						x			expensiveness
~ to walk						x			interest
~ to ride a bike						x			ride
urban functions							x		exploration
meet|retire								x	projection|identification
atmospheres|cultures								x	identity

Fig. 19 Possible differences to experience at different ages and radiuses[a]

Fig. 19 shows a number of environmental differences that could potentially be useful for design as legend units. Their relationship with the age at which you probably became aware of these differences is nothing more than a guess. Although this could be a topic for further psychological research, it is not the ambition of this study. In the following section, I sometimes refer to this connection with ages with the sole purpose of making the treatise more accessible to your imagination.

Observing the natural environment

The horizontal differences in the soil largely reflect the *gradual* change of the chemical composition and granular size distribution of the soil. These differences consequently select gradually changing vegetation and the associated animal life. This is the physical basis of biodiversity. You are less likely to find sharp boundaries in nature. Sharp boundaries allow only two different environments. They often indicate a human impact. Vertically, there is a sharp boundary between ground and air, although this boundary is softened by stratification in the upper soil and by vegetation. For example, in a forest, many variables obtain intermediate values (e.g. moist, light, safety, stability, grip) according to the altitude. They offer different environments for different organisms according to their ecological tolerance(see Fig. 188 on page 218). A slope may also produce such gradual change from high and dry into low and wet. Further, any altitude line may show a different composition of species. Exposure to the sun in different wind directions adds gradual differences horizontally. In the natural environment, intermediate values cover the full range of the relevant variables more completely than they do in urban environments. In the urban environment, the many sharp boundaries and contrasts dominate the gradual differences through artificial separations and connections. The relevant variables thus do not reveal their values as easily in their theoretical sequence. Moreover, other environmental variables may be more relevant for humans than they are for plants and animals.

[a] Jong, T.M. de (2005) *Child perception* (Delft) Contribution ChildStreet Conference 26 August 2005

The advantage of a sequence with gradually changing values

The natural environment shows the advantage of gradually changing conditions over sharp boundaries. Gradually changing conditions generate greater biodiversity than do sharply bounded, homogeneous areas without intermediate values. This consequently provides better insurance for the survival of rare species. Our abilities of perception (i.e. vision, hearing, smelling, tasting, touching, motion) are developed in such an environment through evolution. For humans, a gradual sequence of changing conditions would provide more choice and consequently better insurance for spatial quality suited to different stages of experience, ages and lifestyles. Moving around, it offers you a natural balance between recognition and surprise, as intended in *Fig. 6*. The slow change of your environment as you walk or drive a car safeguards both recognition and surprise, and consequently attention. Homogeneous landscapes are boring, while environments that change too rapidly appear chaotic. It is neither easy nor efficient to *build* these intermediate values, however, and it is therefore expensive. Designers must explain more when they draw vague boundaries than they do when they draw clear-cut lines with clearly different, well-known environments on both sides. Clear lines reduce the number of legend units. Talking in well-known categories makes communication flow more smoothly. It saves time.

2.5 Limits of scale

Exploring possible differences

In this paragraph, I explore the kinds of diversity within different radiuses that we may know from our own experience and imagination 'phenomenologically'. It does not pretend (or even intend) to be complete. It remains a sketch of the problem field. In the next chapters, we may be able to make these problems operational for design, research and policy.

In search for relevant variables at different levels of scale

Let us start to explore several examples at different levels of scale, recognisable by everyday perception, gradually adding experience from different contexts. Perhaps we can discover more values to fill ranges of relevant environmental variables. The more variables you could recognise, the more possibilities you could offer for spatial design. The challenge is thus to distinguish, recognise and identify these primary variables and their separate values as content, apart from the added variables of a higher order. Second-order variables thus concern the possible spatial distributions of the primary values of difference, while third-order variables acquire their mutual connections and separations and so on (the functions and intentions). They superimpose other kinds of diversity. These higher-order variables (e.g. concentration/de-concentration, openness/seclusion, mono-functionality/multi-functionality) regulate the distribution, connection, separation and use of the same content in different ways. For this initial exploration, I do not pay much attention to the distinction between primary and higher-order variables. It provides some examples of variables that may be distinguished in any environmental diversity.

R=1m, 'Grip space'

Child

You may have explored environments R=1m most intensively when you were one year old. Within a radius of 1m around you, differences can be observed in temperature, between hard and soft and in the mobility of objects (see *Fig. 19* on page 59). 'Object mobility' may vary between *meuble* (mobile) and *immeuble* (immobile). You can imagine a range of object mobility (e.g. a wall, a cupboard, a table, a chair, loose commodities and utensils). This range is largely related to the size of the objects. Although larger objects are less easily moveable, designers have the possibility of making them more mobile by providing them with hinges (as with doors and windows), wheels or similar attributes. Smaller objects can be either pendulous or affixed to larger ones. This kind of environmental diversity is important to the sensory-motor development of a child. Children need stable, reliable elements, as well as dynamic ones, which they can move on their own initiative. For example, imagine the fence of your playpen and your toys. The experience of moving yourself teaches you 'distance' and object constancy through parallax. Throwing your toys out of the pen is an exercise in object constancy. It adds a variable ranging from the values 'within reach' to 'beyond reach' and from 'safe' to 'adventurous'.

Adult

For an adult, stable gradients of movability sustain the ergonomically efficient routines of a household between those objects that are used more and less often. For example, in the kitchen, ingredients or utilities that you seldom use are stored in the back of the kitchen cabinet or at higher or lower steady locations. The objects that are used more often are more accessibly located and mobile at eye-level in front or at hand-level on the counter. In addition to object mobility, many other environmental variables (e.g. fabrics, their texture and colour) may determine environmental diversity and the possibilities for diversification by design. A designer can relate these differences to the variable of mobility, assigning different textures or colours to objects according to their mobility. Which variables relevant can you add?

R=3m, 'Room'

Movement and visibility

You may have become fully aware of R=3m environments when you were three years old. Although you are surrounded by many environments with a radius of approximately R=3m (1 to 10m), let us take the room as an example. The potential presence of daylight may be an important variable for environmental diversification within this radius. This variable may vary according to the distance from the windows, which are structures that connect you with daylight, while separating you from low temperatures, wind and rain. Windows determine the relative sensoric isolation of places in the room. They 'structure' the room from sensory 'open' to 'closed'. They create different functional potentials for each place in this environment. You may locate your desk close to a window, while placing your bed in a remote corner. Nonetheless, the positions of objects are not determined solely according to their potential access to daylight. The interior contains additional diversities that remain at night. For example, the distance from doors to the most remote corners also determines the layout from a motoric kind of 'openness' and 'seclusion'. The distance to the walls may divide the room into a largely unbounded centre and peripheral places that are more determined by the walls as boundaries. Zonings around windows and doors constitute a structure that limits your functional possibilities.

More variables

An even earlier question concerns the description of the diversity of place values and the variables to which they belong. This does not yet refer to the structure and operation of a room, with its second-order variables ranging from 'openness' to 'seclusion' or 'shelter'. The fact that content or form may *cause* (or be caused by) structure is not the first issue in a *conditional* sequence, even if structuring is your first priority in design. The challenge of this study is first to distinguish the first-order variables and values that are capable of differentiating places in a room. This 'content' may be a programme that precedes your design. Which other variables are available to enrich, cover, weaken or even avoid these kinds of structural diversity by adding content? The same content still allows different compositions, structures and functions to be chosen by design or use.

R=10m, 'Building'

House, tree, street

An environment of R=10m is the environment you may have discovered when you were five years old. It is also the radius of a large, 50-year-old tree or a large house. An urban environment of R=10m may contain one large or several smaller building units and adjacent gardens or a street to cross. If many rooms together are connected to public space by one entrance, they make up a 'building unit', in which the connections of the rooms with the entrance differ in length. This length differentiates the rooms into categories ranging from remote, more isolated and private rooms to rooms that are more directly connected and open to the street. One challenge may be to design many intermediate values (reinforced by variables other than accessibility) in what Alexander referred to as an 'intimacy gradient'.[a] This gradient can be best unfurled from front to back in a 'long, thin house' with inner courts to provide the rooms with light and air.

Dwelling breadthways accessible

In more usual dwelling layouts, however, you can often recognise the same difference of accessibility breadthways. In this context, the difference appears over a smaller distance as a sharp contrast between the hall and the living room. Even if it is realised at a smaller distance, it belongs to the nominal 10m range of *possible* measures. It is accompanied by

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[a] Alexander (1977) *Pattern Language* (Oxford) OxfordUniversityPress

differences in temperature, moisture, materials, texture, activity and layout. A house with a walk-through lounge on one side may have a hall, a corridor and a kitchen on the other side. On that side, all connections of the house with the external world are concentrated: the front and back door, the staircase, the water, gas and electricity supply, their tubes, the sewage, the mailbox and similar attributes. The walls are often covered by moisture-resistant, easy-to-clean tiles in moderate colours. This environment supports movement and physical activity better than does the living room, with its vulnerable chairs, tables and wall-paper.

Movement and rest

Physical activity does not require much distraction by the pictures, ornaments and baubles that you may like if you are at rest. The concentration of connections on one side of the house protects a more isolated living area from the accompanying dynamics on the other side. The R=10m *motoric* polarity from 'open' to 'closed' between rooms is an extension of the R=3m motoric mentioned above within each room conditioned by the position of the doors, although it has different effects. This polarity is definitely different from the R=3m *sensoric* polarity, to which it often appears in a perpendicular relationship. The R=10m polarity may thus also appear vertically. The decreasing accessibility from ground floor to the attic also conditions the diversification of dynamics and the associated potential diversification of functions between the storeys.

R=30m, 'Building group'

At seven years of age, you may have become familiar with R=30m environments (see *Fig. 20*). An urban environment R=30m may include several buildings, gardens and adjacent public spaces. One of the most striking variables within this radius is once again from open to closed. An environment of R=30m contains external variables different from those applied and applicable in the interior of a building. It shows the contrast between being inside and being outside – the façades on the front and backsides of buildings. It challenges the designer to make such intermediate areas as covered outside spaces and internal open courts. It encompasses the difference between the public residential street and the private backyards and back-paths of buildings. Moreover, it determines the mutual position of buildings and building units, gardens, parking space and public space. The position and orientation of buildings and trees determine variations in the access to sunlight and shadow in the open air, which subsequently cause variations in use and in the character of the vegetation, the location of street and garden furniture. Public illumination, visibility and safety may become important variables. The alternation of planted and paved surfaces, the distinction between pedestrian surfaces with tiles and surfaces accessible to other kinds of traffic with bricks or asphalt usually constitute differences with sharp boundaries. This radius still contains many variables between architecture and urbanism.

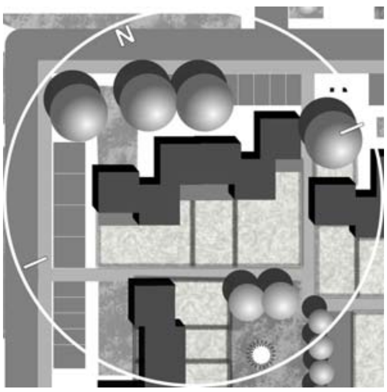

Fig. 20 Building group R=30m

Fig. 21 Ensemble 100m

Fig. 22 Neighbourhood 300m

R=100m, 'Ensemble'

Crossing the street

At nine years of age, you may have become familiar with environments of R=100m (see *Fig. 21*). These environments encompass the ensemble of some residential streets and some different building groups, possibly of different styles. You may have crossed these streets on your own to meet friends. You probably promised your parents not to cross the larger neighbourhood or even district roads, except if that crossing was necessary to go to school. As border crossings of your territory, such crossings were probably safeguarded by adults or by traffic lights. At that time, the further route to your school was probably allowed without deviations. You know them only by the buildings you passed each school day. Your school had thus become your second territory of R=100m, along with its playgrounds and its adjacent sporting fields.

A one minute walk

For many adults this is also the radius of shopping trolleys, of district centres visited every day, of pedestrian ensembles of shops and larger parking spaces (see *Fig. 23*). Some large buildings may have this radius (see *Fig. 24*). The income of the inhabitants may visibly vary within the ensemble. It is also the radius of the smallest parks, which usually have a small pond, surrounded by more expensive houses and their gardens. Which environmental variables determine the diversity you encounter by walking one or two minutes in an urban environment? One of these variables is the distance of direct view at which you can still identify the separate buildings or shops.

A 100m forest vision

This is the distance at which you can survey a forest; it is the environment of dimmed light gradually bounded by trees and bushes. This is where your eyes evolved to have their present stereoscopic abilities and where they obtained their final resolution. It is also the radius of a palaeolithic village of hunters and gatherers, the communities in which humans lived for millions of years before the invention of agriculture made larger settlements possible. The time that has passed since this development (the Neolithic revolution) accounts for a mere 1% of the entire period of human existence. This range is an archetypical radius in which your familiar scope of control within a one-minute walk ends and where the rest begins, filled with invisible noises, uncertainties and dangers. It is the radius within which you still can call your children.

A 100m span of control

Perhaps the most appropriate variable for R=100m environments would be 'span of control' or 'primary scope'. This variable ranges from 'open' to 'closed', but with a character that is different from that of the previous radials. Visual accessibility varies from introvert streets to extrovert crossings and from inner private courtyards surrounded by buildings to public space opened up by streets. Within this radius, there is a wider variety of quietness and business than can be observed at a distance of 30m. It is the average view from the seclusion of your room into the outside world; it is the distance at which you can still recognise people or events that can please or frighten you. For the purposes of this study, however, it is important to know which of these variables are relevant for design and which of them can be strengthened or weakened by design means. For example, why did I never see such a supporting sequential diversification of building groups in a gradual transition from a horizontal into a vertical articulation of their architecture?

R=300m, 'Neighbourhood'

A 5 minutes walk

A contemporary urban environment of R=300m (between 100 and 1000m radius, or between 1 and 15 minutes walking) is usually known as a 'neighbourhood' (see *Fig. 24*).
It is an area of nominally 30ha (varying between 3 and 300ha) and 1 000 inhabitants (varying between 100 and 10 000). A walking distance of 300 metres to a primary school or a public transport stop is acceptable. Within this radius, different ensembles and dwelling types can be distinguished and composed. Each ensemble may house a more or less homogeneous category of inhabitants (with regard to income, stage in the life cycle or lifestyle[a]). In the 17th century, all towns in the Netherlands[b] had a radius of approximately 300m, with the exception of Amsterdam and Dordrecht (R=1km). A 300m radius was apparently an optimal size for a complete urban economy and its defence. Many of its urban functions are currently performed at a larger scale in special neighbourhoods, separated from the exclusively residential areas. A town of R=3km with 100 000 inhabitants may still have a town centre of R=300m (see *Fig. 25*).

Fig. 23 R=300m with a District centre r=100m

Fig. 24 R=300m with a Large building r=100m

Fig. 25 R=300m Town centre

Diversity of age

For example, ensembles may contain either a substantial number of children, primarily adults who do not yet have children or a majority of elderly people. Their allocation may thus be selectively attracted to schools, health care centres, small businesses, shops, pubs and other facilities required for some 1 000 inhabitants. Such facilities may differentiate in terms of content, form, structure or neighbourhood function as these categories crystallise.
The stage in the life cycle may select specific categories of inhabitants according to their specific requirements. For example, if 10% of the population consists of children up to 10 years of age, facilities for playgrounds, crèches, nursery schools and primary schools may attract families with children. These facilities serve as meeting places for parents and as potential sources of social cohesion. You may need some 200 pupils for a primary school, eventually located at the boundary of a neighbourhood, thus allowing it to serve two neighbourhoods. Its requirements with regard to safety, greenery and daily pedestian accessibility may be combined with some other functions (neighbourhood park, homes for the elderly, health care), but they are separated from the more dynamic (i.e. less safe) ensembles.

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[a] Michelson, W. (1970) *Man and his urban environment: a sociological approach* (Menlo Park, California) Addison-Wesley Publishing Company, Inc. Philippines

[b] Blaeu (1652)*Toonneel der Steden* (Amsterdam)

Diversity of life style

This pattern may result in zoning ordinances around primary schools that differentiate the area. The other pole is thus the connection of the neighbourhood roads with a larger external road collecting the traffic from several neighbourhoods. These connections provide access to clients, employment and careers elsewhere. This pole may be combined with smaller starter dwellings in higher-density areas, along with small businesses (including home businesses), services and possibly some neighbourhood shops.
Which environmental variables (kind of plantation, street furniture, enlightening, types of pavement and roads) may support that potential polarity from quiet and introvert into more dynamic and extravert? Such segregation between the familist and careerist lifestyles, however, may also occur at the larger radiuses of a district, a town or even a conurbation of R=10km, with a busy centre for consumers, a well-disclosed transition zone for careerists and silent R=3km suburbs for familists. In these smaller areas, however, the teenagers of these familists may become bored. At this point, which variables may differentiate the R=300m environments?

Larger radiuses expressed in kilometres

Discontinuous view, rarefied zones

Even in your early youth, you may have seen areas larger than the neighbourhoods you knew from direct exploration by visiting the higher storeys of tall buildings or flying in an aeroplane. These views must be connected to earlier experiences (‘Look! We walked there!’). These connections are not self-evident. The known neighbourhoods are separated by rarefied zones[a]. You need some spatial imagination and reason to understand such views, as with the views provided by Google Earth, its applications or the maps of an atlas. In an atlas, thematic maps show a great diversity of legend units within even larger radiuses. You cannot immediately observe these categories on the ground. They may nonetheless be relevant for many kinds of actions, for the understanding of what you see on the ground and for spatial design.

Maps and legends

For example, an authoritative atlas of the Netherlands[b] contains maps distributing many values in space as legend units. Some of these values are listed in *Fig. 26*. They are relevant within different radiuses. I indicated the radiuses within which I could recognise substantial differences by looking at these maps. But, what is “*substantial”?* The colours chosen in the map may suggest differences based on arbitrarily chosen statistical class boundaries, and within a larger radius I may have recognised groups of similar colours as *substantially different* from other groups. Very detailed maps cover more levels of scale. In most cases, however, differences smaller than R/100 are not observable in the map’s frame R. Its resolution is thus <1% in most cases. Smaller distinctions are reduced to an average value for the smallest unit (grain). The *average values* are named in a legend. This legend may show the ordinal sequence of a variable. These values are sometimes numbers (e.g. altitude), but largely the units are distributed on a different basis (e.g. geology). They may relate different values, or they simply may represent accidental (e.g. historical) singularities. Many of these variables are responsible for environmental diversity in more than one radius. The same name may have a different meaning on another scale. For example, within a radius of 10m, the income of your neighbour may be different from yours. You can draw this conclusion if your neighbour’s house, garden or car appears to be more or less expensive than yours. However, the atlas also shows a map with differences of *average* income between provinces within a radius of 100km. This determines a kind of environmental diversity other than that which you have experienced within your own neighbourhood.

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[a] Groenman (1960) *Het disconitue wereldbeeld* (Mens en maatschappij)35 p 401-411
[b] Bosatlas (2007) Bosatlas van Nederland (Groningen) Wolters-Noordhoff

Variables varying within R=	1m	3	10	30	100	300	1km	3	10	30	100	300	100	300	100	Page
altitude											1					183
altitude				1			1	1								205-221
geology									1	1	1					179
geomorphology										1	1					185
water storage capacity									1	1	1					186
lithology								1	1	1	1					189
soil						1	1									188
soil						1	1	1	1	1	1					189
landscapes									1	1	1					201
agricultural occupation types									1	1	1					222
residential environment								1								226
travel time into a centre									1	1						227
land use 1900							1				1					230
land use 2004							1				1					231
allotment					1	1										234
groundwater										1	1					244
catchment basins												1	1			244
hydrology											1					245
subsidence									1	1	1					246
below sea level										1	1					247
flood probability										1	1					248
water-boards										1	1					251
mediaeval dammings										1						252
ecological districts										1	1					260
nitrate							1		1	1	1					276
noise nuisance			1	1					1	1						278
population increase									1	1						296
live expectancy										1	1					368
cancer casualties										1	1					371
smokers and drinkers										1	1					373
economic power											1					402
added value									1		1					403
income					1				1	1	1					404
employment/1000 inh.15-64yr									1	1						413
employment/km^2										1	1					413
unemployment										1	1					417
commuting									1	1	1					420
vegetative agricultural products								1			1					429
pigs											1					430
chickens											1					431
maize											1					433
employment industry										1	1					438
employment distribution										1						440

Fig. 26 Several themes in maps published in the 'Bosatlas van Nederland' 2007

Statistical differences
This discussion raises several important methodological questions that must be clarified before I continue to explore possible variables for each radius. First, thematic maps usually show statistical differences. The different colours of a legend thus represent statistical classes with selected boundaries (e.g. 0-9%, 10-19%). If these classes had been larger (e.g. 0-19%, 20-39%) or smaller, the map would have shown larger areas in fewer colours or smaller areas in more colours. In this case, my conclusion regarding the level of scale at which the difference is 'substantial' would have been different. However, I trust that the authors are experienced specialists. They probably had a reason for selecting their statistical class boundaries and the number of contrasting colours representing them. They must have chosen them according to their experience, in order to bring these differences to my attention as meaningful.

The scale of the legend
Second, some variables may have a meaning at any level of scale, as is the case with differences in altitude (e.g. from table to mountain), although they appear in the atlas only for the radiuses of 3km and 100km. The map showing altitudes at R=100km neglects the altitude differences between houses and streets in order to show the average differences between the East and the West of the region. These choices determine a different environmental diversity. There are many other radiuses, however, within which altitude may differentiate the environment in ways that are useful for *design*. For example, a slope or an inclined street may differentiate the higher urban environments from the lower ones at R=100m, R=30m or even R=10m. I will not refer to altitude as a design tool at every radius. I choose one radius at which it may be most 'substantial' for environmental diversification by design. Readers or designers are free to experiment with their capacity to diversify environments within radiuses other than those mentioned here and in the next chapters. This exercise corresponds with the aim of this enterprise to extend your design tools.

Neglecting what is not measurable
Other questions concern the choice of the actual themes. Do they also cover the *possible* environmental diversity? Do they overlap? Are they probably related as cause and effect, or do they conceal a common variable that is not shown? Conversely, you could question whether a commonly accepted cause and effect (e.g. the relationship between smoking and cancer) may be falsified by a lack of spatial relationship. For example, the map of cancer casualties shows a pattern that is very different from the map of smokers. There may be other variables than smoking (e.g. 'stress') that could explain the number of casualties from cancer. Human stress is difficult to measure, however, and there may be no statistics about it in relation to the surface represented by the map.

Other variables than measurable, true or probable
An atlas is intended to represent the *truth* or at least a *probability* to the extent that it is measurable. This is not the only problem I wish to address. I would also like to address *possibility*, and this cannot be completely covered by empirical research. Design study covers *improbable* possibilities as well (and even in particular), thus *changing* the existing reality. To become fully aware of the problem that this thesis aims to address, it is still important to identify explicitly which differences we can observe, remember or even imagine ourselves within different radiuses. Even then, there may still be categories and variables that do not exist in the usual categorisations of professional empirical geographers.

Exploring possible differences
In the following section, I continue to explore the kinds of diversity within different larger radiuses that we may know from our own direct experience in a more or less 'phenomenological' way. It does not pretend (or even intend) to be complete. It remains a sketch of the problem field. In the next chapters, we may be able to make these problems operational for design, research and policy.

R=1km, 'District'

A 20 minutes walk

A district is an urban area of nominally $\pi R^2 \approx 3km^2$ and 10 000 inhabitants, most of whom usually seek quick access to daily commodities. Walking 20 minutes with children or heavy shopping bags becomes less attractive than driving. Driving 5 minutes in your car as a means of covering a distance of 1km, even if driving would involve some delays due to traffic lights and parking. Broad and busy district roads may cross the district every 1 km through or around a usual district centre for daily commodities. At R=1km, traffic becomes an important issue that structures the district. A district may even have a railway station in its centre (see *Fig. 23* and *Fig. 27*). The railway then would divide the district into two parts.

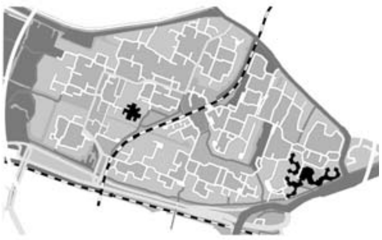

Fig. 27 R=1km Zoetermeer Buytenwegh

Fig. 28 R=1km Zoetermeer Centre and Old Village

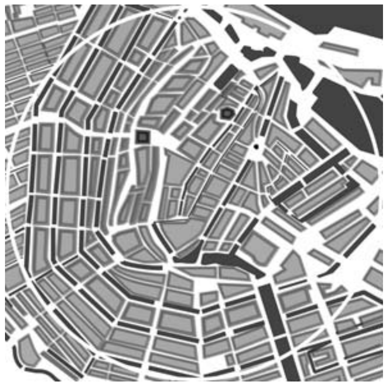

Fig. 29 R=1km Amsterdam Centre

Centre and outskirts

From the district's centre into its outskirts, the kind of dwellings may vary from high-density flats to detached houses with low density and more greenery (see *Fig. 29*). However, the location of a district park of R=300m may disturb this sequence and polarity through its own radiating influence, if it is not located at one of the borders. Other boundaries are often urban highways of 60m in width every 3km (mesh width M) . To navigate through your district, recognisable points, lines and areas[a] (e.g. striking objects, nodes, routes, edges and neighbourhoods with their own style) have become important. Which variables may differentiate these neighbourhoods in ways other than by their location and density? Why would you choose to live in one or the other?

Lifestyle differences

At a radius of R=1km, lifestyle may be more important than stage in the life cycle is as a differentiating factor for choosing your neighbourhood. Lifestyle, however, can also play a role in your choice at a larger scale. If you are a consumer, attracted by centres of shopping, services and leisure, you may be more attracted by the centre of a town or even the centre of a conurbation than you are to the centre of a district. In these areas, however, you are likely to have to pay a higher price. The scale that you choose may thus depend upon your age and income. If you are a careerist, you may choose a drive-in dwelling close to the exit of an urban, a regional or even a national highway. If you are a typical familist with young children, you may choose for smaller towns and suburban districts.[b] Within a district, however, lifestyles may already be a source of mutual diversification amongst neighbourhoods. Which variables would you choose in order to distinguish neighourhoods within a district? The possible local differences in lifestyle may be a starting point, but there should be additional factors for differentiating the character of a district in its own right.

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[a] Lynch (1988) *The Image Of The City* (Cambridge Mass) MIT Press

[b] Michelson, W. (1970) *Man and his urban environment: a sociological approach* (Menlo Park, California) Addison-Wesley Publishing Company, Inc. Philippines

R=3km, 'Town'

Amenities

A town is an urban area of nominally 30km^2 and 100 000 inhabitants. Many of a town's inhabitants find their employment and leisure activities within a radius of 3km, while others commute. If they move, they usually move within this radius in order to acquire a larger dwelling. They visit the town centre (R=300m, see *Fig. 25*) approximately once a week. The number of inhabitants is large enough to support a hospital, a railway station, specialised recreational and cultural facilities (e.g. a library, galleries or theatres). They may attract each other by fulfilling the same leisure demands or supporting additional facilities (e.g. pubs and restaurants). Dynamic functions (e.g. railway stations) may attract other functions, including specific types of shops, fast-food restaurants or travel services. This generates polarities between functions that differ from the previously discussed polarities.

Fig. 30 Zoetermeer R=3km[a]

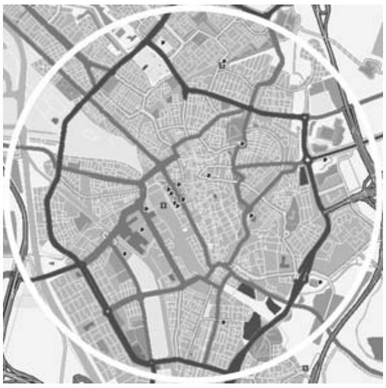


Fig. 31 Utrecht

Fig. 32 Leiden

Crossing your town

Crossing your town in any direction by car in 15 minutes at a speed of 30km/hr, you will pass many differences, although the differences inside the districts may dominate those existing between them. The difference between the older districts in and near the busy centre and the more recently built districts in the quiet outskirts could be more striking than those that can be observed amongst neighbourhoods within a district. It is not only a difference of dynamics, building style or the age of the trees; it is also a different layout. Some older districts may have curved roads, while other districts lead you along long, straight lines with interesting or boring views.

Eccentric growth

That spatially readable history of a town may be manipulated by a kind of planned growth, as argued by Doxiadis.[b] Concentric growth of a town raises pressure on its centre. It expand into adjacent housing neighbourhoods in a sub-optimal, opportunistic way. Eccentric growth creates an opportunity to build a larger new centre next to the old one, removing the same amount of housing areas by public agreement in a master plan. Special cultural or other functions could remain within the oldest centre, as they are not overly sensitive to centrality.

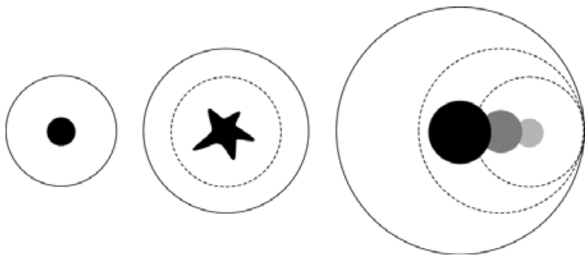


Fig. 33 Concentric and eccentric growth.

[a] CityDisc, Den Haag

[b] Doxiadis, C.A. (1968) Ekistics. An introduction to the Science of Human Settlements (London) Hutchinson

This strategy can preserve or even restore the identity of the old centre. In the new centre, new economic functions can be realised in a highly efficient and contemporary way. In a third phase of urban extension, the dynamics of economic expansion may require yet a larger centre, leaving the previous centre for administrative and other less dynamic functions between the quiet old city and the new economic core. Through this process, the town acquires new linear urban diversification from historic to contemporary and from cultural and administrative to economic. This was the case in Utrecht. From 1960 onwards, a shopping centre was created that extending over the railway station. This preserved the identity of the old centre while serving the western extensions on the other side of the railway. Perhaps you can find additional R=3km variables that could differentiate an urban body in the other directions.

R=10km, 'Conurbation'

A million inhabitants

A conurbation is an urban area of nominally 300km^2 and 1 000 000 inhabitants, often composed of several townships, former towns and villages. The former settlements, each with its own history and identity, may now be captured within a radial web of the central city.These settlements have lost functions in favour of the central core. Their skyline has become less recognisable since their rural surroundings have been urbanised, thus filling in the meshes of the web.

The city

The central core, the 'city' of the conurbation may also have lost much of its original identity. Its floor space may have increased substantially. This would have necessitated the construction of high-rise buildings and the implementation of radical traffic interventions. The decreased accessibility of the inner city, with its restrictions on transport and parking, may have made it necessary to build a separate underground public transport network for commuting and shopping, in order to connect the suburbs with the emerging exclusively pedestrian areas.

The primary meaning of 'environmental diversification' as it appeared in the national plan of 1966 (as shown in *Fig. 15* on page 46) was not a national diversification, but a diversification of residential areas with different densities within a radius of 10km.

Urban highways

The nominal mesh width of urban highways (M=3km) may have been extended by even wider conurbation highways (M=10km) allowing higher speeds surrounding the city and separating it from its suburbs. These ring-ways may have attracted enterprises that require more space and private motorised accessibility than the inner city can offer. At the exits of the ring-way, specialised sub-centres may have emerged for more space-consuming facilities (e.g. hospitals, furniture businesses or financial headquarters). These sub-centres may have radiated their influence into the adjacent suburbs and reserved space in the inner city for new specialised functions. This new spatial division of tasks or 'specialisation' within the context of a conurbation may require a new 'spatialisation' in order to make their differences recognisable.

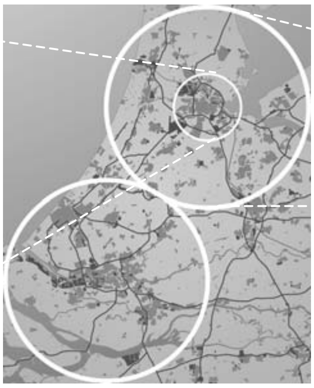
Losing locational value to the internet

In contemporary times, however, jobs and shops are increasingly losing their locational value to the internet. The provision of employment is becoming further centralised into regional highway exits, leaving empty places in the former centres. What is to become of their identity if it should be something else than crime? Shops may disappear in a process reinforced by economic crises. Retail is decentralising further into the home computers of residential neighbourhoods. How can residential areas be diversified if jobs and shops are no longer available to accomplish this task?

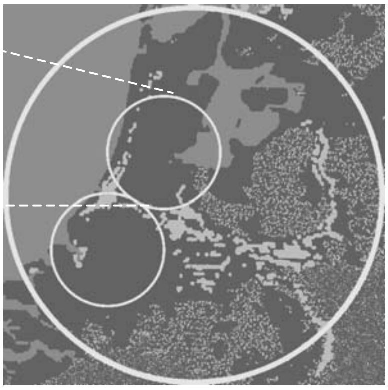
Physical topography

A conurbation may diversify through its physical topography – through differences in its soil, waters and possibly its hills and valleys.

R=10km 2000AD
Fig. 34 Conurbation



R=30km 2000AD[a]
Fig. 35 Urban regions



R=100km 1000AD
Fig. 36 Region occupation [b]

There may be dry, sandy districts and lower and wetter parts on peat or clay, with ponds and waterways. There may be open waterfronts and dry, inner city districts and parts with or without views over the surrounding landscapes. Its centre may be recognisable by high rise buildings. A conurbation may thus contain large open areas with natural, agricultural or recreational functions. They may be scattered over the conurbation. In this case, however, they may not diversify the centre at a scale of R=10km, but at a scale of R=3km or even R=1km. If they form a band surrounding the inner city (thus separating it from its suburban outskirts), or if they form wedges between the urban extensions reaching from the surrounding landscape to the urban core, these functions structure the centre at R=30km. The large and quiet green areas may contrast or alternate with the M=10km highways, which are possibly hidden behind their noise barriers.

[a] CityDisc Den Haag
[b] After Scheele(1990) (Utrecht)UvU

R=30km, 'Urban region'

Amstel dam and Rotte dam

An urban region is an urbanised area of nominally 3 000km^2.
If it is inhabited by 10 000 000 people within its radius of 30km (as is the case with London and Paris), it can be called a metropolis. The urban regions of Amsterdam and Rotterdam (see *Fig. 35*) both show a remarkable symmetry. The Old Rhine flows where they touch each other. This river has been separated by dikes from the reclaimed peat marshes on both sides, descending by drainage. These lowlands were drained by the smaller Amstel and Rotte rivers. The Amstel (which flowed to the north) and the Rotte (which flowed to the South) were dammed (thus Amstel-dam and Rotte-dam), in order to prevent seawater from flowing inwards. In 1000 AD, the Old Rhine was an axis of early occupation between the old towns of Utrecht in the middle of the Netherlands and Leiden in the west (see *Fig. 36*). Utrecht suffered from floods and dammed its useless shallow Rhine branch in 1122 AD. At this point, its water and ships largely followed the southern course along the present harbour of Rotterdam.

Physical history

This example demonstrates the role of physical history in the understanding of an urban region. Rivers play a dominant role in the origin of settlements. Conurbations grow some 30km from the sea or large waters in order to acquire sufficient hinterland within the 30km commuter distance of their urban region. This hinterland may differentiate into different quarters. The Amsterdam urban region has more expensive residential towns and villages within the sandy areas of its south-eastern and western dune quarters. It has a large lake on its north-eastern side, smaller lakes in the south, and open land to the north. The Rotterdam urban region shows less diversity. Its historical core was bombed in the Second World War. Its vast harbours extend into the west. Within its 30km view bounded by the horizon from a 25th floor, it has a vast greenhouse area to the northwest and The Hague, which is the seat of the national government, as a fashionable second conurbation. The other quarters are primarily rural lands with small natural reserves and forests. At its south-eastern boundary, however, lies one of the oldest towns of Holland, Dordrecht (which once housed the Parliament of Holland). On the other side of the river, Dordrecht faces an adventurous landscape of waterways and bushes that are reminiscent of the country's oldest scenery.

A Sunday cycling tour

Which variables could you apply for further environmental diversification at a level of R=30km? Its components are landscapes and townscapes diversified by ecology and history. Its design tools are landscape ecology, regional history and archaeology. At this level of scale, climate change may have a substantial impact on current policy. In the Netherlands, the incidentally expected sudden overloads of water flowing down from Switzerland, Germany, Belgium and France require more room for the rivers. Between their dikes, they are too narrow for that capacity. That policy may result in occasionally flooded river landscapes crossing urban regions. New natural reserves may diversify their environment, thus bringing their inhabitants closer to an awareness of nature and the oldest scenery of the country, in contrast to the fabricated environment of towns. The awareness of history may be encouraged by archaeological reserves that remain hidden in the soil. Looking down into its excavations or looking up to its historical buildings may bring you back to another culture, tacitly confronting you with the current dynamics of your time. You should have access to many of such places of reflection within a radius of 30km. This is the radius of a Sunday cycling tour or the distance of a mediaeval day hike.

R=100km, 'Region'

Cultural diversity

An area with a nominal radius of 100km is often called a region.

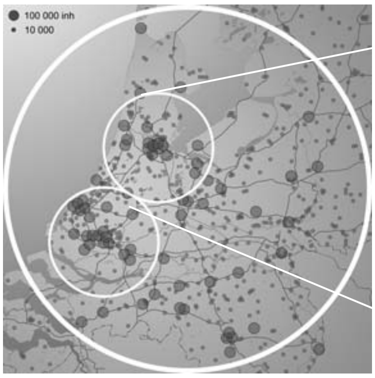


Fig. 37 Region R=100km
with characteristic sub-regions R=30km

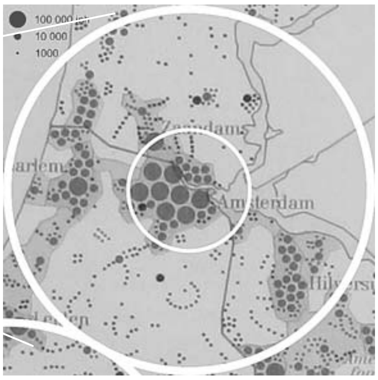


Fig. 38 Conurbation R=30km Amsterdam 1979[a]

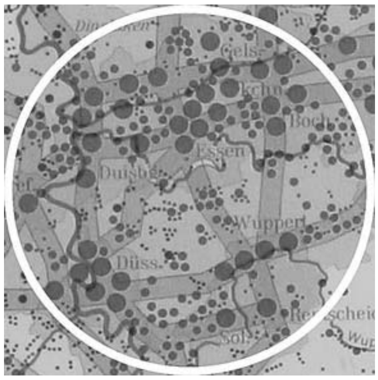


Fig. 39 Conurbation R=30km Ruhrgebiet 1979[a]

Areas of this radius seldom cover a nation, but a small country such as the Netherlands, nearly does. Within this radius, there can be unusual diversity. Even the language may differ to such an extent that people living 200km apart cannot understand each other speaking in their native dialects. This is the case between the North and the South of the Netherlands, which have been historically divided by the rivers Rhine and Meuse. These rivers formed the boundary of the Roman Empire and were an important border during the 80 years of war between the Catholic Spanish heir and the Protestant Dutch Republic fighting for its freedom four centuries ago. The country still shows evidence of these differences in culture on both sides of the rivers.

Soil

Perpendicular to this cultural variable, nature has left behind an even more substantial difference at this level of scale. The higher sandy soils in the east gradually turn into the lower and wetter clay and peat polders of the west. The landscape changes dramatically as you cross the country in that direction. A century ago, the sandy soils were less fertile. Prosperous agriculture in the east was limited to brook valleys. The underestimated invention of artificial manure to be produced at an industrial scale by Justus von Liebig in the 19th century changed the world, however, and it changed the agriculture in the east of the Netherlands as well. Poor soils could now be used for agriculture. This reduced the area of nature in the east and consequently the natural diversity of the region. Is technology always doomed to homogenise our environment, or does it also provide means to diversify it?

Urban and rural

The development of rapid modes of traffic made very large concentrations of people possible. The rural areas consequently became emptier (see *Fig. 38* and *Fig. 39*). This process has diversified the picture within the radius of R=100km. Within a radius of R=30km, it has caused an opposite effect, making the homogeneous sprawl of sub-urbanisation possible. This provides a nice example of the scale paradox (see *Fig. 7* on page 21). Technology has opposite effects of up-scaling and downscaling processes of production and distribution. It raises the question regarding the level of scale at which particular types of diversity are to be desired.

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[a] After Griep(1979)*Atlas Encyclopedie*(Utrecht)Oosthoek

Physical and social differences

Taking the urban regions of Amsterdam and Rotterdam as a starting point (see *Fig. 37*), you may recognise the historic division in provinces as surrounding sub-regions of equal size. Although they show a clearly different identity, it is difficult to identify the variables responsible for this diversity. If you study the maps of a national atlas, you will find numerous spatial, ecological, technical, economic, cultural and governmental values as legends (see *Fig. 26*). Many of these values, however, determine the diversity within radiuses much smaller than the R=100km scale of the map. How should you identify combinations of these as values of 100km variables in order to acquire a grasp on the potential diversification of a region?

Economic specialisation

Fifty years ago, some of these overall differences were more recognisable than they are now. Amsterdam was the centre of culture, Rotterdam was the centre of trade, The Hague was the centre of government, Utrecht was the centre of conference and other cities were the centres of industry, different branches of agriculture or specific services. These clearly distinguishable characteristics disappeared. The advancement of technology made any place suitable for any purpose. Any sub-region now has its own facilities for culture, trade, conference, industry, agriculture and services. If you would like to find more contemporary characteristics, you should perhaps consult leisure and travel folders rather than an atlas. They try to convince you to visit particular regions because of their unique character.

R=300km, 'Land'

Lands

In Europe and the US, the 300km radius is largely the radius of states or lands.
The term 'land', may have a less governmental connotation than 'state".

(light) <90..100(EU)..110..120.. (2011)   (201201) <4..6..8..10..12%..(dark)

Fig. 40 Europe Altitude[a]

Fig. 41 GDP/inhabitant and Unemployment R={1000,300km}[b]

The environmental diversity of lands R=300km is largely determined by physical differences. The physical differences are the result of long-term geological processes locating the sea and the land, culminating in its higher mountains (see *Fig. 40*).These differences determined the catchment area and the course of major rivers (e.g. the Rhine see *Fig. 42*). The river Rhine has attracted people and their economic activities, thereby resulting in a densely populated axis in Europe with relatively small dispersed cities (see *Fig. 43*). A ring of large solitary metropolises surrounds that area clockwise: Hamburg, Berlin, Vienna, Milan, Lyon, London and Birmingham.

[a] European Environment Agency (EEA) http://www.eea.europa.eu/data-and-maps/data/digital-elevation-model-of-europe
[b] Eurostat(2012) http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

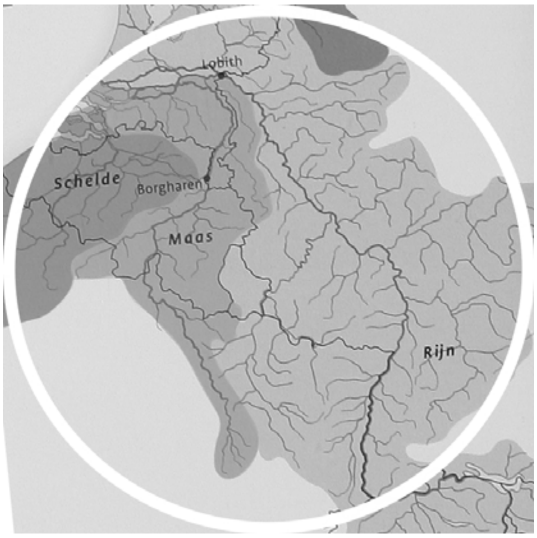

Fig. 42 Catchment areas R=300km[a]

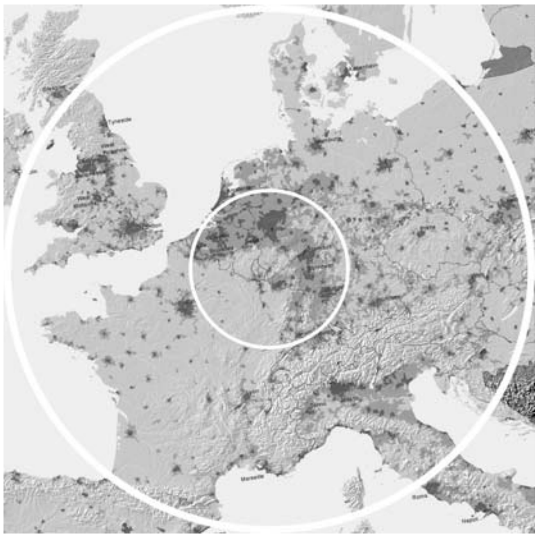

Fig. 43 Urban density R={1000km,300km}[b]

A historical coal mining area crosses the Rhine supporting its industrial core (Ruhrgebiet). The economic diversity of primary (agriculture, mining), secondary (industry) and tertiary (services and trade) sectors has historically been conditioned by this physical zoning. Many economic variables (e.g. Gross Domestic Product, unemployment see *Fig. 41*) follow such diversity, but they change according to a global shift of sectors.

The level of scale conditions the content of diversity

From a phenomenological …

These examples are not intended to be complete. They are a first step exploring the problem of environmental diversification without any other assumption than the concept of scale. They merely demonstrate that such a concept may acquire at least 12 very different contents. The composition of variables responsible for environmental diversity changes throughout the scales. A fundamental study of environmental diversification from the perspective of possibility should start by ordering these variables systematically according to the scale of their working. If they work out differently at different levels of scale, they should be distinguished further to encompass their environmental working. For example, if ‘altitude’ diversifies R=1m environments in manner other than it does within R=300km environments, the variable ‘altitude$_{1m}$’ will be different from ‘altitude$_{300km}$’. Their frames and grains differ.

…into an operational content

Chapter 3 will try to make variables operational for design practice. Even then, however, it remains a trial run. Its selection continues to contain the subjective element of a choice from amongst a multitude of imaginable variables. This study may encourage to add your own variables, in order to enrich the supply of design tools in any radius. Despite the unavoidable incompleteness in studying the content of environmental diversity, it still allows the study of diversity in the ways in which their values can be dispersed within an environment (morphological diversity), combined (structural diversity), used (functional diversity) and intended (intentional diversity). The analysis of these meanings of diversity are thus not completely dependent upon a correct determination of the available variables. These meanings will have their own limitations, however, thus limiting the questions and problems to be addressed in this study.

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[a] Bosatlas(2007)
[b] Eurostat(2012)

2.6 Limits of 'diversification'

More than content

Content is the basis of environmental diversification. This study is limited to contents that can be expressed in variables, categories that can be divided in subcategories with a rational (not necessarily quantitative) sequence – in other words, 'values' or 'legend units'. This study subsequently assumes that any single well-defined variable of this content still has many different possibilities for dispersing its values in space (i.e. forms). If this distribution has extremes (e.g. accumulation and sprawl), the distribution itself may be expressed as a variable of second order. The morphological diversity covered by this study is thus limited to the diversity that can be expressed as values of this second-order variable. There may also be a third-order variable for structures that stabilise forms, a fourth-order variable for functions using structures and a fifth-order variable for intentions steering functions. Although the search for variables imposes substantial limitations on the enterprise, the possibilities remaining within these restrictions are infinite.[a] This section is an attempt to achieve further limitations.

Artificial and natural diversity

In the previous section, I acknowledged and identified several environmental variables at 12 levels of scale. In the rest of this study, these variables must be elaborated and extended. Nevertheless, they will never cover the full diversity of environments ever observed, imagined or even possible. The advancement of technology will enable new possibilities that will surprise us as they have before. However, these advancements may increase the environmental diversity only at some levels of scale, while decreasing it within other radiuses. This has happened before as well. For example, our homes currently house fewer people and have more rooms on average than ever before, and they are filled with more furniture, clothes, utensils, pictures and books than ever before. This variety in the home may serve to compensate for the sensory deprivation we may experience elsewhere. Young children today are still discovering a world full of things that they have never seen before, but teenagers have seen it all earlier. They become bored by repetition in space and time. They want to meet other people, they look for adventure, they want to travel. If they do, they discover the same kinds of buildings, hotels, shops, rooms or utensils everywhere. They have unlearned the urge to kneel down and take a closer look at the peculiar plants and insects they may pass. They can impress their friends more by wearing the latest fashions. Compared to the inconceivable diversity that we inherited from nature within any radius, our artefacts look poor. Once they cease to be handiwork, they are produced in large series without variation from one item to the next.

Lost diversity

The human population is increasing in numbers as never before; it has conquered large areas of nature and covered it with buildings, pavement and parks with cloned plantations. The house you once bought for its magnificent view lost that advantage as new buildings have spoiled it, decreasing its exceptional value. Environmental diversity has become concentrated in the interior of your home. Even in this environment, however, the variety of change may be lacking. This bothers your teenagers. The majority of the neighbourhoods, districts, towns and conurbations on Earth are environments that are boring to the human senses and experience. People stop looking at the television or the newspapers because they contain no 'news'. Journalists desperately looking for news may find ever fewer peculiar facts to report. You have read it all before. Our production reaches the limits of globalisation to produce the largest series possible. The television and the newspapers become filled with advertisements for new things that are not actually new anymore.

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[a] The Dutch poet J.A. Deelder expressed it as follows: 'Within the limitations, there are as many possibilities as outside'.

Urban diversity

When was the last time that you went out for a walk in order to enjoy your neighbourhood (as your younger children still do), your district or your town, or for any purpose other than to visit its shops? What did the urban designer do to make it an adventure, gradually alternating the view and changing as the weather and the seasons? The only changes that may invite you for a walk are your neighbour's new car, a demolished building or an accident. An urban designer cannot do much if people do not wish to pay for anything other than private property. In this preference, they are being pennywise and pound-foolish. They have forgotten the impact that other aspects may have on the value of their houses should they decide to sell them or when they calculate the value of the mortgage. Urban designers also cannot do much either if they have unlearned the habit of using design instruments and variables for environmental diversification within radiuses larger than R={1, 3, 10, 30m}. What can be varied at these larger scales? It is difficult to find relevant variables, and I do not want to limit their number. This number has already been limited too much by a lack of imagination. On the contrary, the reader is invited to add more variables, given that a lack of content is accompanied by a lack of form, structure, function and choice.

Distribution, a second order variable of form

If the content has been sufficiently explored in terms of variables, the possible distributions of their values in space ('form') can be studied. Even if that study is restricted to the possible distributions of one legend unit at one level of scale, however, it cannot cover the full range of all possible forms. It cannot cover all black-and-white pictures that will ever be made, let alone all works of pictorial art that are *possible* using a single colour. What should we think with regard to additional colours (legend units) and levels of scale? Such is the case with spatial design. To neglect this kind of differences is to make the study irrelevant for spatial design. In this light, what limitations would be useful for studying morphological diversification?

Distribution between accumulation and dispersion

Within a radius of 10km, it appeared useful to study the theoretical extremes in the distribution of floor space, built-up, paved or green space. At a given level of scale with a determined frame and grain, the zero point is total *dispersion*. 'Distribution' is thus a second-order variable ranging from total (regular) dispersion or sprawl to total accumulation. For example, it bounds the differently coloured values of *Fig. 15* between these extremes. The extremes themselves can be drawn as a complete dispersion of a given black surface (in its smallest units) over a white field, resulting in either a dotted grey or a single black dot with the same black surface (accumulation).

Diversification by partial concentrations

Any change within this homogeneous grey field of regularly or irregularly dispersed dots is a kind of concentration, a partial accumulation that may produce a pattern of agglutinations, be they lines or surfaces (e.g. the road system, the floor space, the built-up area, the green area). Such diversification of possible dispersions within a radius of 10km formed the foundation for thinking about environmental diversification. In this study, it provides a starting point for the study of morphological diversification at any level of scale. The limited interpretation of 'form' as 'state of distribution' limits the morphological study in a way that is relevant for design. It leads to the question of whether it can be applied to other variables and other levels of scale.

A combinatoric explosion of possibilities

This approach, however, still does not answer the question of how to cope with drawings containing more than one colour (i.e. more than one legend unit) dispersed within the same drawing. The distribution of one colour conditions the possibilities remaining for the dispersion of a second colour. Changing one distribution changes the possibilities for the second. Designing changes both. Designing rearranges legend units that represent categories of use and construction, with the ultimate goal of achieving optimal mutual contact or distance. Designing arranges connections and separation. It creates *structure*. This involves more (or less) than checking all combinatoric possibilities of dispersion. There should be a shortcut for avoiding this type of endless exercise.

Relations between variables and values

The preceding discussion leads to the question of how adjacent legend units are related to each other as values of different variables and how they attract or repel each other according to different criteria. If there are c categories or legend units, c(c-1) relations will be possible. In empirical research, variables are usually related to each other supposing a determined sequence of their values. A value x_1 is thus related to y_1 in the same way that x_2 is related to y_2 and so on, generalised as y=f(x), although this is seldom the case in a drawing. Legend unit x_1 can be drawn adjacent to y_2. This may produce a spatial relation that differs from the general relation y=f(x). It increases the number of possible relationships between every pair of values y_n,x_n, up to n_{max}^2.In empirical research, relationships are usually well defined; if possible, they are even defined in a quantitative sense. What if they cannot be quantified? What if the categories x and y are gradually changing into each other through a vague boundary, thereby producing varying xy mixtures at a lower level of scale, effectively producing a new variable category z between them?

One-sided and many-sided relations

In a drawing, the relationships are never one-sided. A mathematical function y=f(x) is one-sided. A change in an independent variable x causes a change of a dependent variable y. This function may be rewritten as x=f(y) in order to find a reverse relationship, if it has any meaning at all. For example, if visibility (y) is a function of distance (x) according to y=1/x, the reverse function x=1/y would mean that distance would be reduced by increasing visibility. This is nonsense, however, or poetry at best. It switches cause and effect. Increasing visibility cannot be the cause of reducing distance unless its possibility motivates you to move. If this is the case, however, the reverse relationship will introduce other variables (e.g. motion and time). The reverse relationship must be formulated separately as a different function.

Double-sided asymmetric relations

In a drawing, the adjacent values condition each other in both directions, often with unpredictable effects due to numerous context factors. The variables may also change by the hour, day or season. The effect of x on y may thus cause y to have a different on x, just as two neighbours can have an increasing conflict due to successive teasing or because a tree is blocking light to a building (or conversely, because a building is blocking light to a tree).

Hampered relations

Moreover, the values in a drawing may be separated or connected by additional intermediate values, such as walls and windows or dikes and roads (structure). What should we do if these intermediate elements acquire a substantial size as a new legend unit at a higher resolution than a sketch may show?

From values into their boundaries

It may be useful to shift the attention away from the values towards their spatial boundaries. The degree of separation or connection at the boundaries between values is a third type of variable that regulates form (and subsequently content). The content of a room with open windows or doors is different from the content of a room in which the windows or doors are closed. As in the case of form, there are clear extremes of separation and connection in all directions. These extremes may be called ‘closed’ and ‘open’, with different degrees of ‘openness’ and ‘*seclusion*’ in between. These third-order values can be indicated clearly in a drawing.

Seclusion, a third order variable of structure

This leads to the question of whether this reasoning can be applied to any structure, scale, form and content. After all, the drawings of designers consist primarily of lines. These boundaries or links separate or connect spaces that have different functions. These functions are conditioned by specific kinds of seclusion or openness of the area, and they are readable in the drawing as the position of lines. Clients specify only some of the functions. They ask the designer to draw a structure that may house these functions. Experienced designers know that clients tend to overlook functions that are difficult to name and those that may determine the value for subsequent users or owners, should the realised project ever be sold. Experienced architects deliver more possibilities, which pay for themselves if the building must be sold. Moreover, there are always many possible structures for housing the same function. For this reason, the set of possible structures in *Fig. 4* is larger than the set of possible functions. There are also many more design decisions to make than are required to house the intended function.

Multi-functionality, a fourth order variable of function

The primary limitation of functions considered in this study is the restriction to functions for humans and society. I do not study the function of the sun for the moon, or the reverse. This is hardly a restriction, however, if people are aware of the function of nature for humans. Any function for plants and animals may thus have a function for humans and society as well, be it positive or negative.

Positive and negative functions

This leads to another question. A positive or negative function of nature for the human population is different from the positive or negative function of the human population for nature. If you consider people as part of nature, this distinction discriminates between a function of the whole for the parts ('inward function') and a function of the parts for the whole ('outward function').[a] This distinction is elaborated further in Chapter 6.

Inward and outward functions

If any component of a structure has a special function within this structure, then 'structure' comprises a set of functions. As shown in *Fig. 4*, the functions intended in this study are thus primarily restricted to outward functions, functions *of* someone or something *for* a larger structure. In that case, this study would exclude the apparently inward function of nature for the human population. It was precisely this function, however, that we included in the previous paragraph (i.e. if people are aware of the function of nature for humans, then nature has a function for humans).

This paradox can be resolved in part by distinguishing different levels of scale. The scale (i.e. its frame or radius and its grain or resolution) determines that which we call a structure. A park may have a function for a town, which subsequently functions within a landscape. These are different functions. The town is the primary structure determining the function of the park, but the landscape is a structure that conditions the function of the town. If 'park' and 'landscape' are considered as being more 'natural' than 'town', the question can be reduced to the issue of what is meant by 'nature' or by 'humans and society'. Even these terms are scale sensitive. If you speak about 'nature', 'humans' or 'society' in an abstract or a very general sense, without mentioning the intended radius, it may have no use for design. By definition, spatial design also has a level of scale. Many concepts are tacitly scale sensitive in this way. The 'function of nature for humans and society' can thus be outward, as with the function of a park for a town.

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[a] Berting, J.(1976) *Ruiltheorie* (Intermediair)0528

Reasoning from parts into the whole and the reverse

Even in physics, however, it has proven impracticable to calculate complex chemical processes outward from the observed behaviour of the smallest elementary particles. For this reason, chemistry continues to exist as a discipline, taking the behaviour of particles within atoms as a black box, with a relatively predictable average behaviour of atoms. A biological example is provided in *Fig. 126* on page 184, in which a primarily outward approach starting with the behaviour of singular cells is followed by an inward approach to the organism that these cells ultimately produce, in order to remain practicable for understanding. In the same way, it appears practicable to change the primarily outward approach at some point into an inward approach as humans enter the scene. Even if the bottom-up approach is theoretically possible (and even preferable for exploring *possibilities*), it is not practicable. The question is, on which point you will shift from outward to inward description in order to achieve an optimal understanding that is useful for design.

Functioning in a structure

As shown in *Fig. 4*, a function assumes a structure within which it has the function, even if that structure is not explicitly named. Without clarity about this structure, however, it cannot be clear what the function actually is. In theory, this is the 'inward turn'. If 'structure' is scale sensitive, 'function' must also be scale sensitive. A shop may have a function for the town and for the region. The function that it may have for you at the scale of your household is only a small part of such a function. If you were the only client, the shop would not survive. The function of the shop plays out within the larger retail structure of the town or the region. At other levels of scale, it may also be a meeting place, a source of income for its owner, or it may be an asset or nuisance to the shopping centre in which it participates. Any object of design may have many functions, be it a building, a neighbourhood or a town. Only some of these functions are listed in the program of requirements a designer may receive upon starting an assignment. How is a designer to cope with the multitude of more and less explicit functions of (and between) spatial objects in order to determine the functional diversity of an environment and its value?

From functions into their differences

It may be useful to shift the attention away from the functions themselves and towards their differences. Any spatial object or any spatial set of objects may have many functions at different levels of scale. The *number* of the object's functions thus produces a fourth-order variable known as '*multi-functionality*'. Objects in space can be more or less multi-functional. A road is less multi-functional than a dwelling. The zero point is 'mono-functional' or even 'useless'. At this level of abstraction, you can still draw interesting conclusions. For example, you may conclude that mutifunctional facilities save space but cost time, while mono-functional facilities save time but cost space.

Functionless space

Places without any actual use may attract the interest of project developers. The place then acquires a function, as a project developer intends to earn money by creating new spatial functions. This demonstrates a special kind of function: intentions. Many functions, amenities, affordances have no demonstrable intention (e.g. the Earth upon which we stand, its gravity, the air we breathe). In addition, you may also desire functions that do not exist, but that are nevertheless possible. These functions motivate action to search for them or to create them.

A fifth order variable of intention

There are more intentions than there are people. People without intention either do not exist or will soon die (e.g. if they do not at least have the intention to eat). On the other hand, people with too many intentions may face a majority of failures and lose their initiative. Most people, however, have several realistic intentions, aims to achieve and motives for actions to realise the functions they want. Individual and common intentions change the human

environment, giving it function, structure, form and content.
You cannot observe the intentions of others, but you can ask about them. If you do not trust their answers, you can observe their *sequence of actions*, which apparently lead towards some result.

Interfunctional actions
I refer to these intermediate actions between initiative and result as '*interfunctional*'. It is typically human to accept many interfunctional actions before the apparently wanted result can be achieved.[a] Animals may show this capacity in a very limited way, often in the form of innate and sometimes learned routines. Learning, earning and saving money, organising, making plans and executing them step-by-step are examples of interfunctional actions that show intentions.

Design as an interfunctional action
A spatial design is such an intention. Its successive interfunctional actions propose the structure, form and content of an environment (often in the reverse order) before it is realised by other actions and before the intended function is finally achieved. If predictions about the environment of your intended actions fail, scenarios may be useful for design. Scenarios describe possible futures, whether desirable or not. They allow you to check whether your design will retain its desirable value in the different futures that they present. Although this value may be expressed in money, this is not a proper variable for intentional *environmental* diversification.

Public intentions
Intentions differ in the space and time covered. Individual intentions can be unified in a common policy and legislation of a town, a nation or of states united in a parliament. This offers a scale-sensitive variable ranging from private to more public. Public interests, however, largely represent the average of private intentions. Moreover, this variable does not distinguish the majority and the greatest diversity of private interests. There are many more private intentions than there are public interests, and private interests are more diverse.

Solofunctional actions and levels of scale
The private intentions of persons, families and enterprises can cover very different levels of scale. Intentions of a small scale in space often have a small time span as well. They require fewer interfunctional actions. The number of interfunctional actions required for any intention may be an interesting variable. A 'zero-interfunctional' action is any action that immediately satisfies. I refer to these as 'solofunctional actions'. Such actions may show a relationship with the multi-functionality of an environment. A multi-functional environment (e.g. a home) may satisfy multiple needs at once. Interfunctional actions are often specialised within the sequence of actions required to achieve the desired result. They are thus best supported by mono-functional environments that may save time with regard to the more satisfying actions – and the more time that mono-functional, self-satisfying actions take, the better. The question remains, however, 'What is "satisfying"?'

A sequence of functions and intentions
Maslow's theory of motivation[b] offers an interesting 'prepotency' sequence of human needs. This sequence may even apply to policies at levels of scale that exceed personal intentions. The theory comes down to 'physiological needs first' (see *Fig. 44*). If you are hungry, you will forget about any other intention until that need has been satisfied. In order to obtain food, you even may forget safety. Once you are no longer hungry, however, but in danger, your stress will cause you to skip over any intention other than looking for safety.

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[a] Harrison;Weiner;Tanner;Barnicot(1964) *Human Biology* (Oxford) The Clarendon Press
[b] Maslow, A.H. (1943) *A theory of human motivation* (Psychological Review 50)50 p 370 - 396

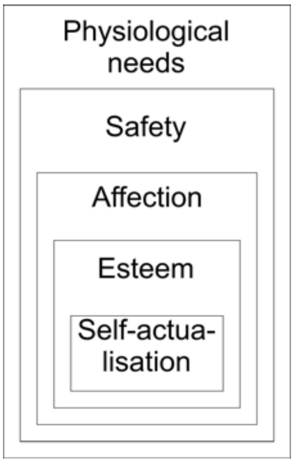

Fig. 44 Maslow's sequence

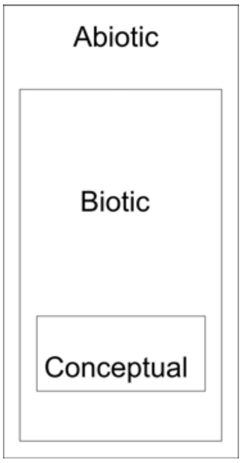

Fig. 45 ABC sequence

Fig. 46 Environmental layers

Even some of your physiological functions slow down while others accelerate in order to prepare you optimally for fight or flight. You even hold your breath while your heart beats. Your home should provide safety first, after which it should afford space for affection, and it could possibly provide you with prestige and self-realisation. It does not matter whether you agree with this Maslow sequence: affection, prestige and self-realisation. Its principle of prepotency can produce a fruitful variable for distinguishing values of intention. Even a national government confronted with hunger, flood or war will stop discussing the taxes, social services, environmental issues and similar topics in order to address the crisis at hand. The theory demonstrates the possibility of a sequence of functions that cannot perform before the previous functions have been fulfilled.

A conditional sequence of intentions

Chapter 6 transforms and extends the prepotency sequence of human needs into a conditional sequence according to a simple 'ABC model' (see *Fig. 45*). This model is useful for distinguishing functions that providing combinations of conditions. A selection of this list provides a summary of successive conditions that an *environment* can fulfil as its 'layers' (see *Fig. 46*). You may recognise scientific disciplines or ministries of a territory-bound government. In all of these sequences, however, any condition requires some fulfilment of the previous ones. The degree of fulfilment determines a 'sufficient level' for the next step. The most urgent motivation or intention thus becomes the next condition of the sequence to be fulfilled, unless a previous condition fails. In such a case, there is a relapse of intention. A previous condition will appear more urgent and gain priority (e.g. more funding).

Multi-functional and solofunctional

What is to be done if the last condition is achieved? A hypothetical environment that fulfils all imaginable conditions is self-sufficient, multi-functional and filled with mono-functional actions (i.e. leisure). There is no need for delay by interfunctional actions and consequently intentions. Such an environment represents a hypothetical zero point of intention, as supposed in spontaneous wild animal life.

Nature might be considered a self-sufficient environment if it were free of human intentions and management (nature preservation). If you consider money as an accepted delay of payment, you can buy time for your interfunctional actions. By employing others, you can fill your time with cultural, managerial or purely mono-functional activity, as if you were living within a self-sufficient environment.

Intentional environmental diversification

How can we distinguish intentional *environmental* diversification? It is possible to imagine two environments that are equal in content, form, structure and function, but still different by intention. At some levels of scale, these environments may have spatial plans. These plans can differ as well. Spatial plans may give an impression of the private or public intention of the environment and the range of interfunctional actions required to achieve the intended use, be it interfunctional or mono-functional at a lower level of scale. Nevertheless, this still does not tell us how we should distinguish intentional environmental diversification if there are no written or drawn spatial plans.

Intentions observable through actions

Intentions become observable through interfunctional actions that end in mono-functional actions. There can be a substantial delay before the mono-functional action appears, and it may have no relationship with the preceding interfunctional actions. Some of the interfunctional actions are paid. Some of these paid interfunctional actions require mono-functional environments. Mono-functional environments may be observable as industrial environments or office environments. Even if interfunctional actions are not paid, you can recognise them by environments that reveal interfunctional actions of traffic and transport. Although interfunctionality may be an appropriate variable for intentional environmental diversification, I fear that I will not be able to provide sufficient answers to the questions posed above.

2.7 Limits of method

Modes of research and study

Possibility search

In the eyes of an empirical researcher, a designer should seem a liar.
A designer draws objects that do not exist. They are not true. They are not even probable. They often fail to satisfy the existing needs, as they are clearly demonstrated by proper empirical research. In some cases, design even seems to *create* needs.

Created needs

'Created needs' (or the deficiencies for which they compensate) may have existed tacitly before. In such cases, design has merely brought them to the surface by revealing new possibilities. If something is apparently not possible, you will eventually stop wanting it after all. You may conceal it as a secret frustration, but you do not express such needs. They sound childish.

Fulfilling tacit desires

When completing questionnaires for empirical research or marketing, you do not enter: 'I want to work magic!' When Steve Jobs designed a magic box, however, everyone wanted it.
No research has predicted that some people would terrorise the world with a knife.
No economic research has predicted that lending money would cause a global crisis.
The usual context that the pledge can be sold if the debt cannot be paid changed. Such improbable possibilities of context-change are usually not included in the rules, variables and parameters of scientific models.
In order to become aware of these possibilities, you must design scenarios, different possible futures, different conditions as input for probability calculations. While models usually take much of the current context for granted, spatial design intends to change it.

Programming and evaluating research

The search for different possibilities calls for another kind of study than is required by the search for general probabilities or even truths. Given that possible futures include the probable futures, this kind of study may *include* empirical results, while exploring a wider field. Its core is even outside the field of probabilities. Its core consists of finding *improbable* possibilities. Probability calculations do not produce designs. Statistical operations can summarise verbally well-defined existing needs. This is known as programming research. Once the design has been made, statistical operations can be used to evaluate its probable effects on the satisfaction of only these needs. This is known as evaluation research.[a]

Means-directed study

Nevertheless, possibility search is not merely aim-directed. Desired functions can still be fulfilled in many ways. Possibility search must select materials (content), their dispersion in space (form), their connections and their separations (structure). These are the design means for fulfilling a function in one of its many possible ways. You must cope with this inconceivable *diversity* of possibilities. You can always make your solution different from any existing solution. If it is not different, it is a copy, not a design. Means-directed search often reveals different, unexpected possibilities that are not represented in any query. What could you do with a touch-screen? What could you do with a knife? What could you do with a pledge? What could you do with a heap of bricks, cement and wood?

The paradox of generalising diversity

A study of possible environmental *diversity* touches upon the core of design (more than simply copying or combining). When confronted with empirical research, however, it

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[a] Jong;Voordt(2002) *Ways to study* (Delft) DUP-Science

encounters a remarkable paradox. Empirical science and the humanities intend to generalise characteristics and rules from as many facts as possible. By doing so, they *reduce* the very diversity that you wish to study. How can you study *diversification* if the existing methods of study *equalise* different cases into a more generally applicable theory? How can you study *environmental diversification* if you must assume that your results are valid only *ceteris paribus* i.e. in a *similar environment*)? This study does not aim to *reduce* the diversity of environments; it aims to discover how to *produce* it.

Diversifying theories

Algorithms repeating the same rule at an ever-decreasing scale (e.g. fractals) or reacting by different rules on predefined environments (e.g. cellular automata, agent-based computer programs) can produce a kind of diversity. This diversity, however, is based primarily on self-similarity or reaction-similarity. It changes (or reacts in) the same single variable (in most cases, colour on a flat plane). The patterns that are produced may remind us of biological or even urban forms, but this has nothing to do with the structural and functional diversification of cells (embryology), the development of specialised organs in an organism (epigenesis) or the selection of species by an environment (evolution). They are determined by many variables at the same time. Repeated application of the same rules may appear in epigenesis and evolution, but it is not their core. Epigenesis and evolution assume that the rules can change upon encountering a different environment. It also includes improbable mutations of the rules, which an environment may or may not accept for survival. The environment selects in the long term, while the organism reacts in the short term.

Evolution as a conditional theory

You cannot simulate an evolution producing the inconceivable biodiversity that we face by applying a few simple rules, however amazing their computed results may be.[a] There is definitely a diversity of rules followed by different species, partly coded in their genes. These rules can also change by accident or upon encountering a different environment. This suggests a rule that rules the primary rules; it suggests a rule of the second order, if such is a rule at all. Evolution theory is thus an exceptional theory. It accepts the influence of an environment and the associated changing rules that are completed by accidental mutations. It thus accepts a kind of conditional thinking. It can clarify the past, but not only by pure causation. It cannot predict, and prediction is usually expected from a theory. For the purposes of this study, however, it is encouraging to note that there is at least one broadly accepted theory that can clarify diversification instead of reducing it. Evolution theory nonetheless *assumes* environmental diversity without clarifying it or telling how to sustain or to *produce* it.

Conditions passed along to other disciplines

Evolution theory takes for granted a necessary condition for biodiversity: the a-biotic diversity and dynamics of the Earth's surface. This condition is its starting point, a hidden assumption. Its clarification is left to other disciplines (e.g. geology and the soil sciences), which subsequently leave some of their crucial assumptions about climatic conditions to climatology. In their turn, climatologists leave their assumptions about climate change to economists and astronomers. Astronomers then pass the ball to physicists who, upon meeting the boundaries of their universe, pay a visit to the Pope.

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[a] Wolfram (2002) *A new klind of science* (Champaign) Wolfram media

Specialised treatment

Something similar may occur if you visit a medical doctor. If your complaints do not fit into any of the diagnoses of your doctor's discipline, you find yourself embarking on a journey along a series of medical specialists, probably ending with a psychiatrist. You are unlikely to be referred to an architect in order to change the conditions that made your complaints *possible* (your chair, your stairs, the ventilation of your room). In the early 20th century, urbanists and civil engineers made the greatest contribution to increasing the life expectancy of urban populations by applying their hygienic measures in cities. Medical treatment added played a much smaller role in the doubling of the life expectancy.[a]

Limits of theory

An empirical theory largely concerns probabilities summarised in a causal sequence. The police may have a theory about the murder, a doctor about the disease, an astrophyicist about the beginning of the Universe. A theory always has a limited clarifying capacity. The police cannot say much about the disease or the doctor about the beginning of the Universe. A theory meets its boundaries in the tacit assumptions about its conditions – and there can be many conditions before an inference is useful.

Cause as the last added condition

Suppose you read in the newspaper that a collision was 'caused' by one of the drivers losing control of the steering wheel. Suppose an extraterrestrial being comes down and exclaims, 'What nonsense! A collision is caused by two objects moving from different directions arriving at the same moment at the same point!' At this point, you must admit that, if the cars had not been moving and one of the drivers had lost control of the wheel, there would have been no collision. If the extraterrestrial being is right, the newspaper must be wrong. It did not mention the preceding conditions of movement, directions, moment and point. It noted only the last added condition (losing control of the wheel) as a 'cause' – and even that was not the real 'cause'. The real cause was the absence of an expected avoidance of the collision by the driver. The driver might even have been planning suicide, and not have lost control of the wheel. Even if you follow the inference of your extraterrestrial being, however, many more conditions will remain to be fulfilled when analysing the movement, directions and so on. Suppose that, shortly before the collision could happen, a tree had fallen down between the cars or that they had lost their wheels, used all of their petrol or developed a malfunction in their motors; perhaps their brakes jammed suddenly. In any of these conditions, there would also have been no collision. These conditions are all very improbable, but they are possible, and improbable possibilities are the object of design.

A design is a set of conditions

The moving of a car without external traction once was very improbable. It was made possible by the design of an appropriate steam engine and, shortly thereafter, the petrol engine. Beyond the development of this engine, however, many other conditions had to be fulfilled (e.g. a steering and braking mechanism, a proper road, a skilled driver). All of these conditions were necessary in order to make an automobile possible. Nevertheless, these conditions were not the *cause* of its motion. A set of *conditions* make its motion *possible*. A cause might have been that someone wanted to drive a car. The design was the set of conditions that made this use possible. Design is a set of conditions, not a set of causes.

[a] McKeown, T. (1976) *The Role of Medicine: Dream, Mirage, or Nemesis?* (London) Nuffield Provincial Hospitals Trust
McKeown, T. (1979) *The role of medicine - dream, mirage or nemesis?* (Oxford) Blackwell

Research

Solving a problem by removing its cause or conditions

A problem (a probable, but not desirable future) is usually solved by removing its cause. To find the cause, you may need empirical research (probability search). Alternatively, you could also remove one of the many preceding *conditions* that made its occurrence possible. This possibility is often overlooked, as it requires ‘possibility search’. If you remove such conditions, or the last condition to be added (the ‘cause’), you may disturb more functions than only the problem to be solved. To compensate for these functions, you need an aim (a desirable and possible, but not probable future). To realise this aim, you need a plan for creating the conditions for its realisation (a design). In its turn, however, this aim is also a design. It is an improbable possibility and, as such, it cannot be created by research.

Internal research problems

The *formulation* of the aim of problem-based research also represents a kind of possibility search. The aim precedes the actual research. It is external to this kind of probability search. The aim is derived from an identified external social or technical problem. The research will not solve that problem; it merely searches for its probable cause, usually resulting in advice recommendation to remove that cause. Following this recommendation, a decision-maker can ask a designer to develop a plan for *how* to remove the cause. Such a plan, however, would represent yet another mode (i.e. possibility search). The internal research problems (which could be part of a research proposal) are different from the identified external problem (which could be part of an assignment). Research problems must be foreseen and written in the mode of the research itself (probability search). They analyse the external problem in order to derive a hypothetical but probable cause-effect chain (a theory), which must be tested through research. The summary of what must be checked provides an indication of what must be done (and paid). It may be necessary to check additional theories, or the theory could be branched (if…then…). This would increase the number of cause-effect links in the chains that would need to be checked as separate research problems to be solved. The shift in mode away from a possibility-searching aim definition towards a probability-searching summary of problems you are probably facing in the actual research is not easy.

A second mode switch for the method

Summarising the research problems still does not answer the question of *how* you should cope with these problems. This is a question of method. After summarising the research problems stemming from the aim of the research, you need a research plan (i.e. a ‘design’ of the research, a road-map). *Met-hodos* is Ancient Greek for ‘the way along which’. That also reflects a shift in mode. A method is a *conditional* sequence of actions, not a *causal* one. The previous action does not cause the next action, it makes the next action possible. For example, you can only study data if they are collected first. If the research problems can be solved by usual methods, it is sufficient to name them. If not, you must invent and explain the data in the mode of possibility search. This is easier for designers than it is for researchers.

Design study

An external *field* of problems and aims for design study

In most cases, a spatial-design study does not involve *one* external problem to be 'solved' and *one* external aim to be 'achieved'. It faces an external *field* of connected problems, along with a *field* of aims, as represented by the different possible stakeholders and specialists involved. The translation of the external field of problems according to this field of aims into a summary of design-study problems cannot consist be one-dimensional and *causal*. Such translation requires a 4D *conditional* sequence. It should show spatial possibilities instead of linear probabilities. This summary could be called 'theory' or 'hypothesis', but it is ultimately a design-concept and plan, which must be checked by the stakeholders and the specialists (most of whom are empirical).

A proposal for design study

A proposal for design study should thus contain an overview of these two external fields and one or more design concepts to be checked. It must be checked by specialists with regard to the probability of its desired effects and by the stakeholders with regard to its possibilities. At this point, the actual design study may start, elaborating the concepts, and alternating with internal or external empirical checks. The shifts between these different modes are not easy. It is also not easy to determine the phase in which and the aspects on which it should occur. It is for this reason that evaluation research is so often postponed. Its planning can be a part of your proposal. Such a promise may be more convincing to the client.

Limits of method

The method of design can seldom be explained in advance. There are more methods than there are designers. The method may change during the design process. Although it is sometimes standardised by companies (e.g. in a chain of shops), it is not published in such a way that you can simply refer to it. The method is largely accepted as a freedom for the designer. More methods may produce more possibilities from which to choose. Your arsenal of methods is your repertoire, as demonstrated by your portfolio. It may have been part of the client's criteria for selecting you as a designer. For an empirical researcher, this kind of study is a mess without proper scientific limits. There are limits, however, albeit different from those that are well documented in empirical research.

Limits of scale

First, a spatial design has a scale. Even if your design study does not have a specific location, it still should have a scale. This scale has an upper limit (frame) and a lower limit (grain). You do not design the entire world down to every molecule. To do so would require a drawing much larger than the Earth itself in order to be readable. To fit on your desk, it should be divided into one for a radius of 10 000km, 100 for a radius of 1000km, 10 000 for a radius of 100km and so on, up to 10^{34} drawings for the radius of 1^{-10m}. These drawings must then be multiplied by the number of phases of execution that you promise in your proposal. This process would result in a pile of paper 10^{30} km high. At any level of scale, you will need other legend units, as known from other disciplines (e.g. geography, biology, chemistry). No client would believe you if you were to make such a proposal.

Limits of effort

Even if you only want to study one or more neighbourhoods with a radius of 300m, detailed to the level of a building with a radius of 10m, you would need at least one sketch for the radius R=300m, 10 for R=100m, 100 for R=30m and 1000 for R=10m. This calculation still supposes only sketches. A sketch has a limited level of detail. For example, a sketch may have no grain and precision of location smaller than 1/10th of its frame. You can also make more precise drawings for R={300, 30}, but the effort is the same. However, you do not have to make all 1111 sketches or 101 more precise drawings. You can select several characteristic examples.

Limits of resolution

It may nevertheless be useful to determine these limits more precisely than usual. Do not promise too much. Select a frame and grain that are close enough to each other to avoid piles of paper. Moreover, every intermediate scale range between your frame and grain has its own design means. The legend of a regional plan is clearly different from a legend that would be useful for drawing the interior of a room. A regional plan has no chairs and tables. Although such images may be useful as metaphors for generating ideas, you must still translate them into legend units that are operational enough for evaluation and execution. You can draw a ‘window on the sea’ for the region of The Hague, but you must still tell what kind of gap in the wall (the dunes) you may intend at a regional scale in order to obtain this ‘window on the sea’. Only after you have done this can the specialists evaluate the effects. The civil engineer in your design team will probably warn you about flood.

Effects without limits of scale

The *effects* of the object of your design are not bound to scale. If you want to save energy by design, it may have a global effect.
Although empirical research may study scale-bound objects as well, its samples should stem from a larger scale. The ultimate intention is to draw more general conclusions that are applicable within this larger scale (which is usually not well-defined or limited).

Limits of context

Second, even if the object of your design study does not have a location, it still assumes a context at any level of scale. You may have many tacit managerial, cultural, economic, technical, ecological and spatial suppositions about these contexts at different levels of scale. You may assume that the national legislation (or any decision-maker or manager) will accept the kind of design that you are going to study. You may assume that the neighbourhood will like it, that there are clients or users who need and can afford it, that it is technically executable, ecologically favourable, and that there is sufficient space, time and material to realise it. If these assumptions do not hold, there is a problem to be studied.

Limits of levels and layers

At each *level* (e.g. nation, region, town, neighbourhood), however, each *layer* of these contexts (managerial, cultural and so on) may limit the possibilities of your design object. It is useful to make these possibilities explicit before you start the actual study. You can include them in your proposal, where they could generate the probable set of problems the proposal must solve. They could generate the desirable set of aims (i.e. a desired future or, even more precisely, a program of requirements) that the proposal must fulfil.
You tacitly assume that your object of study will create possibilities for meeting all of these problems and aims. In different stages of your study, they will be checked by managerial, cultural, economic, technical and ecological specialists and stakeholders. You would nonetheless do well to question whether all of these possibilities are equally relevant within the case you are going to study. How should you balance them in order to determine which stakeholders and specialists you wish to be present in your team?

Limits of impact

Before you start the actual design study, and even before you have determined its object, you can clarify the effects of this assumed object. It concerns the effects that you *wish* to achieve, as well as the effects that you may *expect*. These are substantially different. The first kind of effects belongs to the desirable future, while the second kind belongs to the probable future. By making them explicit in advance, you can clarify the field of problems (probable but not desirable) and the field of aims (desirable and possible, but not probable) of your study. This largely requires you to be explicit about the future context of the design object you are proposing. This could have many immediate advantages for your proposal.

- Such specification protects your study against evaluations that contain other assumptions about the future context.
- It raises awareness of the robustness of the object in different future contexts.
- It makes the results of your study comparable to other studies in similar contexts.
- It raises a proper 'field of problems' to be solved in a design concept, instead of presenting an empirical summary of isolated problems that neglects the side effects of their separate solutions.

The context of an impact

The impacts of a design object depend upon this context. If the municipal management has a traditional culture, but your client is open to experimentation, an experimental design will have a different effect than it would in the reverse case. Once you have made that context explicit, you can estimate the effects that your object of study may have, as well as the problems you may encounter. You still need not be explicit about the actual impacts. It is sufficient to estimate the level and layer of the context at which the effect can be expected.

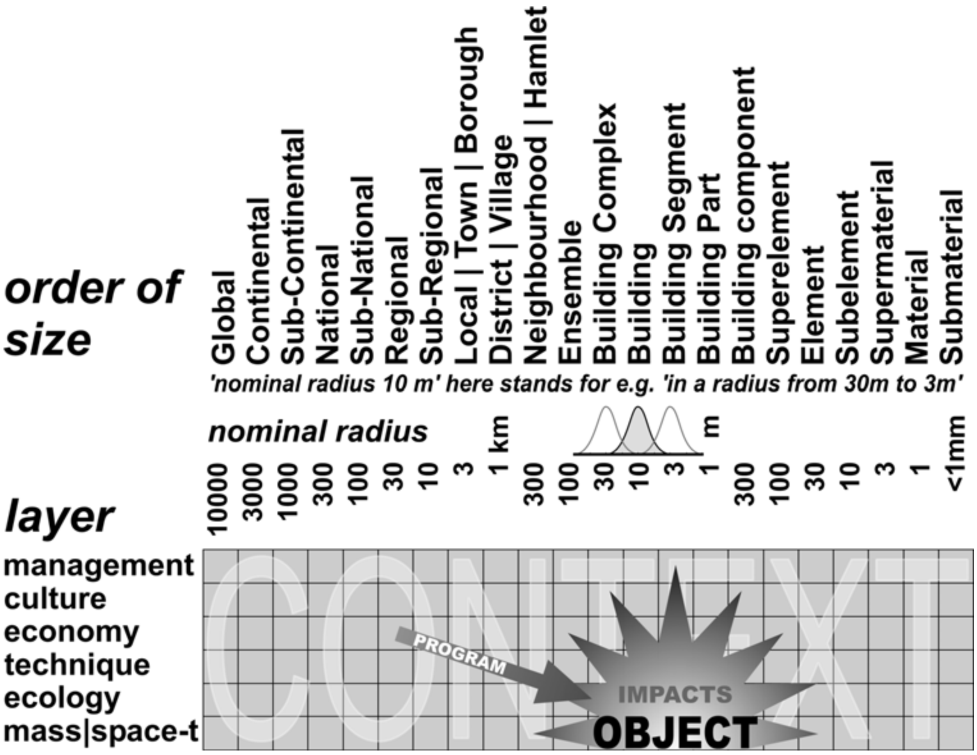

Fig. 47 A matrix of levels and layers of context

This has a number of additional advantages.

- It indicates the kind of stakeholders that may be willing to pay for the positive effects.
- It could produce a field of aims that is broader than those specified in the client's program of requirements.
- It makes you aware of problems that could cause negative effects.
- It indicates the kind of stakeholders and specialists that you need in your team.
- It clarifies your personal interest in and fascination with determining the object of study.

All of this can be accomplished before you have even chosen the actual object .

A matrix of an object and its context
You can simply create a matrix of possible context levels and layers (see *Fig. 47*). You may change their categorisation and limits). Determine the grain and frame of your proposed object, and begin by placing it in the lowest layer. A spatial design should have mass, take up space and remain in place for some time. Be sure to position it within a limited range of scales, thereby limiting the number of drawings you will have to make or to study, thus reducing your effort and the cost of the project. Beyond the object, the rest is context.

Intended and necessary impacts
During the period of its existence, the object will have impacts at other levels and layers of this context. Some of these impacts are so positive that a client will be willing to pay for them. Clients may express their desires in a program of requirements. Nevertheless, you may anticipate additional positive effects and – in all honesty – some negative effects as well. Place plus and minus signs where you want or anticipate them. This will locate the field of aims and problems of your study. Do not put too many of these indicators in the matrix, as this will lead your client to expect reports on all of them. Write down your hopes and fears for every plus or minus.

The future context determines the impact
Once you have *located* the effects in the matrix, you can elaborate their *character*.
The effect of your object in any cell of the matrix, however, depends upon its future *context*. Which context might you implicitly expect there? In order to make this probable future context explicit, you will need an identical second matrix in which to notate your expectations. You need to be explicit only in the cells in which you predicted any effect in the first matrix. At the layer of management, you may place exclamation points or question marks (!,?) at levels at which you anticipate either active management (full of initiatives) or management that waits and checks only whether your initiatives conform to the law and current policy. The effect of your design object may be very different in these two cases. At the layer of culture, you may choose between experimental (>) or traditional (<). At the economic layer, you may distinguish between expected growth (+) and decline (-). At the technical layer, you may distinguish between apparent combination, connection (x) or division, separation (/) of functions; at the ecological layer, between an expected process leading to more diversity (|) or more homogeneity (=) of the population or its habitat; and at the layer of mass and space-time, between concentration (C) and de-concentration (D). For example, urban ensembles may show an accumulation of buildings (C_{100}), which are nevertheless dispersed spaciously throughout a neighbourhood (D_{300}), thus providing many open spaces at that level.

Scenarios of probable and desirable contexts
What you have done in the process described above is nothing other than creating a scenario and an impression of the probable and desirable impacts of a possible object within that scenario (see *Fig. 48*). You can create additional scenarios (see *Fig. 49*) in order to determine the ‘robustness’ of a design in different situations. A ‘robust’ design performs well in a variety of different scenarios. If you make an office building in a period of economic growth within the municipality in which it is located, it is ‘robust’ if it can change its function in periods of decline. This may be included in the broader program of requirements for the object, which your client may have forgotten. By creating such scenario matrices and determining the impacts of a designed object, you limit the field of problems and aims for your design study. The field is still less limited than a clearly defined problem for an empirical study aimed at finding a cause. Empirical research is less context sensitive than are design studies involving a single object that has yet to be designed within a given context. The empirical study requires a sufficient number of similar objects in order to justify more general conclusions at a larger scale. It accepts a *ceteris paribus* assumption that a design study cannot afford.

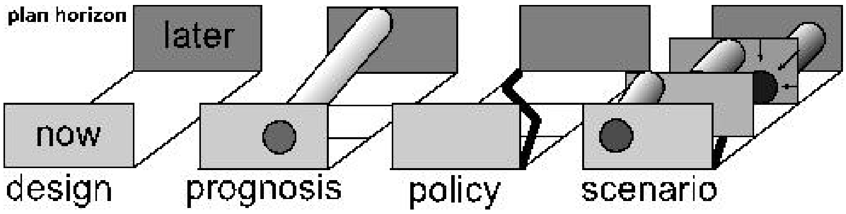

Fig. 48 Possible, probable and desirable futures in a scenario

Fig. 49 Four scenarios on 2 x 2 alternatives

Object and context in design-related study

If you study existing designs, call it research. Otherwise, call it study (see *Fig. 50*). Evaluating the probable impacts of an existing design within a given context is design research. Comparing designs in different contexts and searching for means of design is typological research. In this case, you may find ‘types’ that are apparently applicable in different contexts.

	OBJECT *Determined*	*Variable*
CONTEXT *Determined*	Design research	Design study
Variable	Typological research	Study by design

Fig. 50 Context sensitivity of design-related studies

Use the term ‘study’, and avoid the term ‘re-search’ if the actual design has not yet been determined (i.e. if it has yet to be designed). In this case, there is no existing physical subject of research. If a context has been given, however (as intended in the previous paragraphs), call your work a ‘design study’. In this case, the context is the logical starting point for limiting this kind of study, as you apparently have nothing else. The way in which you can accomplish this is described above.

Study by design

Study without a determined object or context

What should you do if you have no physical object and no context ('study by design' in *Fig. 50*). For an empirical researcher, this sounds bizarre. How can you start a study without a subject and even without a context that could provide a problem and an aim? It has no limits. This kind of study resembles that which empirical researchers scornfully call 'a solution looking for a problem'. It is this precisely this type of study, however, that has produced great inventions with great impact. Instead of starting with the aims, it begins with the means. Means-directed study (or 'study by design') still does not solve any existing problem. The problem is an open question. What could you do with steam, electricity, semi-conducting materials, glass, brick, concrete? The only aim is to have fun or to satisfy curiosity. It is not immediately a question of how you can *use* it, but how it behaves in different contexts, which forms and structures it can take, or what its *possibilities* are.

Black holes

On the other hand, study by design *seems* to have no object and no context. Thus far, 'design' has always assumed a physical object with a form and a structure (if not actual, then at least possible). This is a hidden assumption, however, developed within the previous context of this thesis. Electricity may also have no immediate form or structure, but it does have an observable behaviour (i.e. a 'function' in a sense that extends beyond 'use'). Before you actually know what it is, 'something' may exhibit interesting phenomena that can be studied. If you experience attraction and observe sparks as soon as you rub a piece of amber, you may develop theories about the phenomenon. Can pieces of amber burn through the heat of rubbing, producing sparks? What is then the source of the attraction? Although you may conceive of a mysterious subject of study and call it electricity, what you observe is attraction and sparks. You observe a peculiar behaviour between the amber and a piece of cloth after rubbing. You may try to achieve the same result with other materials, rubbing the amber in other contexts (e.g. under water, in moist air, in other gasses, in a vacuum, with or without light, noise, wind, or when thinking about something). You perform experiments. You perform experimental study without a determined subject. After all, the subject is observable only through its behaviour. Many even more abstract subjects have been named and studied in a scientific way, observing only a behaviour or a function.

Useful imaginary objects

As the story goes, Newton saw an apple falling, thereby exhibiting a force equal to its acceleration times its mass. He could not observe the actual force, but only its effect: the impact in the grass. He simply conceived of something pushing or attracting *outside* the apple and called it 'force'. He did not see 'acceleration' either, only the falling behaviour of the apple. He even did not observe the 'mass' of the apple, which he conceived as an internal feature. He only could only see its size and feel its weight. Its weight, however, was apparently not the mass itself, but an *external* force, which pushes more or less *on* your hand. This 'more or less' may *depend* upon some internal feature of the apple (or of any other physical object), but it is not that feature itself. The mass of the apple could also not be its size, given that a cannon ball of the same size weight more than an apple. Newton referred to this imaginary internal feature as 'mass'[a] and made it a subject of study along with the other properties. However imaginary, he was able to *quantify* these virtual

[a] He should have known that mass does not influence acceleration. Already a century earlier, Stevin had climbed the slanting tower of the Old Church in Delft (Netherlands) and dropped two cannon balls of different weight. He could not hear any difference as soon as they reached the ground. In his experiment, he by-passed 2 000 years of superstition, since Aristotel had claimed that any object itself has a 'will' to fall. This locates the force inside the object. It is thus inconceivable as something separate from its internal mass. Galilei published these findings 30 years after Stevin climbed his tower, although he probably never climbed the tower in Pisa, as another story goes. He also bought a telescope in Middelburg (Netherlands) as soon as it had been invented there. He then discovered the phases on the moons of Jupiter and gained some understanding of their continuous circular 'falling', which balanced the centripetal forces and gravity.

'subjects'[a] and even to measure some of them. He created a mathematical function using these subjects as variables. He connected the variables in a theory, which was probably useful in the wars of England when applied to cannon balls.

Pragmatism and possibility

Since the time of Newton, the scientists of the Anglo-Saxon world have largely been 'pragmatists', as Peirce[b] called them later. According to pragmatists, 'True is what works'. If you can win the war by using a nuclear bomb, Einstein's theory that mass itself can be converted into energy must be true. Although Europeans questioned the actual 'existence' of Newton's subjects of study, I still do not know (or understand) their answer. In my opinion, their existence is *possible*. Leibniz, quarrelling with Newton about their simultaneous invention of infinitesimal calculus (which is required in order to calculate the falling of apples and moons), was the first to understand the utility of possible worlds for understanding the actual world[c] as one of the *possibilities*. Over the course of more than two centuries, however, everybody forgot this insight, until Lewis demonstrated how to cope with them in the context of formal logic ('modal logic').[d]
I nonetheless have doubts about the appropriateness of the right context.

Theories useful for design

Anyone who draws a building in perspective knows how useful vanishing points can be. Although they do not 'exist', they *could* exist as towers on the horizon at the end of the crossing roads lining the buildings. You draw them to reconstruct a realistic impression. A 'theory of perspective' demonstrates the *possibility* of drawing many buildings in different positions. A camera uses a construction of lenses based on a different theory, but with the same result. A camera, however, cannot choose the location of the buildings. Different theories have different limitations. A theory is a construction intended to show limited possibilities. It connects and separates earlier impressions in a particular way. It structures them. The remaining possibilities must be checked through experimentation.
For example, a detective may have a theory about a crime. It may be simulated on location in order to conduct closer examination and in order to determine whether it is possible at all. Could the armed criminal see the victim from that position, shoot the victim there and fly by in a car without being noticed? That experiment may change parts of the theory. The criminal may have used another position and another road. Has anybody seen a car parked there in the hours before?

Theory is an eye

Theory is an eye, a means to see things upon closer examination. At the same time, it is also a hand, convenient for planning, designing or making things. The criminal once had a plan as well. He or she may also have visited the location before. There, the criminal may have checked whether the plan would be possible at all, just as designers do. Nothing is more practical than a good theory. A bad theory is dangerous, however, even if it seems to have worked so well so often. Economic theories seemed to work so well – until the crisis came.

Variables and legends of a drawing

Any theory relates categories (e.g. mass and acceleration with force, vanishing points with lines in a drawing, the possible positions of a criminal with those of the victim).
If a category (a set) can acquire a well-defined sequence of its values (i.e. elements of the

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[a] Newton(1687) *Philosophiae naturalis principia mathematica* (Internet) http://members.tripod.com/~gravitee/
[b] Peirce(1992) *Deduction, induction, and hypothesis* **IN** Houser, N.; Kloesel, C. *The essential Peirce* (Bloomington) Indiana University Press
[c] Leibniz(1710) *Theodicy* (London 1951) Routledge & Kegan Paul Limited http://www.gutenberg.org/browse/authors/l
[d] Lewis(1918) *A survey of symbolic logic* (Berkely) University of California Press
http://archive.org/details/asurveyofsymboli00lewiuoft
Kripke(1976) *Naming and Necessity* (Oxford 2007) Blackwell
Divers(2002) *Possible worlds* (London, New York) Routledge

set), it is called a variable. 'Well-defined sequence' thus means that the differences between subsequent values are of the same kind, albeit smaller than the differences between any pair of non-subsequent values. The kind of difference can be nominal, ordinal or quantitative.[a] A theory is limited by its chosen variables, although the 'choice' of values within each variable remains free. In a drawing, the *legend* may represent one or more of such *variables*. The legend *units* represent their *values*. The gaps in the theoretical sequence of a variable (values never observed before) may indicate new *possibilities*. As a kind of study by design, you can search for the possibilities (still limited by the defined variable) of intermediate values as new legend units. You can even search for new variables by making new legends. Both produce new possibilities or means for design.

Disturbing the sequence by design

Empirical data are usually ordered in a well-defined sequence. In a drawing, however, the values may be accidentally adjacent. If $\{x_1, x_2, x_3 \ldots. x_n\}$ are the values of a variable x in a well-defined sequence 1, 2,…n, the legend unit x_3 may still appear next to x_{16} in a drawing. For example, European statistical data about branches of business are ordered as follows:[b]

A - Agriculture, forestry and fishing
B - Mining and quarrying
C - Manufacturing
D - Electricity, gas, steam and air conditioning supply
E - Water supply; sewerage; waste management and remediation activities
F - Construction
G - Wholesale and retail trade; repair of motor vehicles and motorcycles
H - Transporting and storage
I - Accommodation and food service activities
J - Information and communication
K - Financial and insurance activities
L - Real estate activities
M - Professional, scientific and technical activities
N - Administrative and support service activities
O - Public administration and defence; compulsory social security
P - Education
Q - Human health and social work activities
R - Arts, entertainment and recreation
S - Other services activities
T - Activities of households as employers; undifferentiated goods (and services)producing activities of households for own use
U - Activities of extraterritorial organisations and bodies

You may question whether it is a well-defined sequence. Even if it is, your examination of a map may reveal more different neighbours than any sequential pair. For example, you can find a manufacturing business (C) next to an educational institution (P). If 'Branches of business' with values {A…U} is assumed to be a variable, the difference between C and P is assumed to be larger than the distance between C and D. Be that as it may, what *kind* of difference has determined this sequence? Is it relevant for the design of a school next to a manufacturing business or for the design of a neighbourhood at a larger scale and with more kinds of business?

The kind of difference covered by a variable

Many differences are relevant for design. Examples include the number of employees in each company, the number of visitors (dispersed throughout the day) and their economic

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[a] Stevens(1946) *On the theory of scales of measurement* (Science)103 p 677-680
[b] http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

value or nuisance to the environment (at different levels of scale). By sorting variables according to these characteristics (differences), you can create new variables (e.g. 'number of employees per company' and 'amount of nuisance per company'). Relating these variable on an xy graph may reveal a relationship – an empirical theory – although this still does not solve your design problem. What you can locate next to what, and how many parking places will you need? How you can add or avoid functions in order to achieve synergy?
Some differences (e.g. the amount of nuisance) appear to be relationships in and of themselves, even if they are presented as empirical values (e.g. 'the average nuisance of x'). Nuisance, however, is always a nuisance *of* x *for* y. You can thus create a matrix containing the list of companies {A…U} on both the horizontal and vertical axes, thus producing a 21x21 matrix. One of the cells will report the possible nuisance of a school for the manufacturing company, while another cell will report the reverse nuisance of the manufacturing company for the school. Although such a matrix could be useful for design neighbourhoods, they are seldom used. You may ask, 'Why not?' The answer is that such matrices can raise a multitude of doubts and questions.

Inward averages useless for design

The values above still contain very different kinds of companies, and the levels of nuisance reported between are averages, which are useless for design. The branches of a company may be subdivided much further than shown above (actually some 1 000 branches), but that would require a matrix of 1 000x1 000. Even then, the matrix would report averages that would probably not fit the particular school and particular business at hand. For the design of a particular school, the kind and amount of nuisance should be specified (e.g. noise, odour, risk), in order to determine whether some of these kinds of nuisance can be easily mitigated by the actual design as an improbable possibility. Outward averages within the grain of design, which are not involved in the actual design (e.g. the pressure tolerance of brick or the stress tolerance of steel), are useful for design. Many inward averages (e.g. climate, demography, available technology, economy, culture, management) are also useful for determining the context of design. In contrast averages at the scale of the actual object of design are not useful. If design searches for *improbable* possibilities, statistics and calculating probabilities are unlikely to help the design. They could perhaps be useful as a motivation for *deviating* from the reported average.

A search for variables and their values

Empirical research and design nonetheless share a common concept: the variable. Variables can be used to search for probabilities *and* possibilities. Suppose you observe a building with a garden and you want to study it. An empirical approach could then be to define 'building' and 'garden', to collect more cases of that combination, to select an appropriate number of measurable variables and to look for similarities in their relationships, in order to generalise them in a theory. It is unclear, however, how you could use variables in design studies.

A search for differences

You could start by asking yourself what the *differences* are, even in that singular case. You may discover such contrasts as stone/soil, built-up/green or closed/open. You could then try to imagine something designable between these extremes (e.g. stone/*gravel*/soil, built-up/*pavement*/green, closed/*covered outside space*/open; (see *Fig. 51* 1). In doing so, you would thus *create* variables that could possibly be useful for research and design. Nevertheless, the variables mentioned here, still have no more than three values.

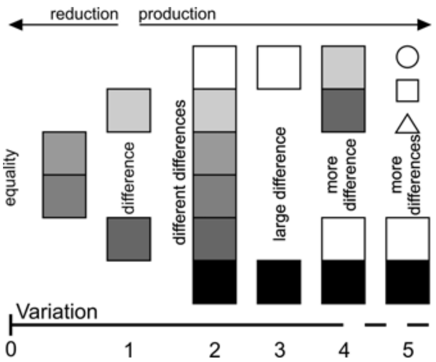


Fig. 51 Searching for differences

radius in m	built-up / green	built-up / water	built-up / pavement	green / pavement	water / pavement	green / water
30 000	national sprawl	building at the coast	mainports	green lay-out of highways	Afsluitdijk	Waterland
10 000	green heart	dream of the estate agent				Casco-concept
3 000	bufferzones				Tjeukemeer	3 networks concept
1 000	urban green		noise nuisance	roadside maintenance	harbours	bank recreation
300	district green		opening-up		boulevards	
100	neigbourhood green				quays	
30	ensemble green	drainage				slope
10	court or garden					
3	fragmented green	Venice	building line			
1						campsheeting

Fig. 52 …,their possible borders and design problems

Try to find more intermediate values (see *Fig. 51* 2) and draw them. Then look for extremes (see *Fig. 51* 3).). Is there something more built-up than the built-up area that you see? You may conclude that there are grades of built-up between one-storey and high-rise buildings. Extend your variable. Is there something greener than the green you see? You may conclude that there are prairies and tropical rainforests, with many green environments in between. You may also conclude, however, that a tropical rainforest is the greenest environment on Earth. You found a zero-point. Now you can give your variable a name. If you cannot find one, do not choose the zero-point, but the other extreme: 'built-up'.
I must now mention a point that I have previously neglected: at which levels of scale are these variables able to be designed? The variable 'built-up$_{10m}$' may receive a different meaning from 'built-up$_{10km}$'. Reformulate the intermediate values for any scale, if necessary.

Improbable relations

Empirical research searches for probable relations between variables to get a more generally applicable theory. I suppose that the majority of cases of buildings with gardens would demonstrate a strong relationship between the variables you found. Nobody would be interested in such results, however, if they are self-evident.
Design produces *improbable* relations. Could you imagine a reverse relation? Could you imagine 'built-up' connected with 'soil' and 'green' with 'stone'? Draw green walls and roofs, deviating from the average relation. Add other variables drawing them. Check the possibility of other improbable relations beyond the well-defined sequences of the variable (see *Fig. 51* 4). If they seem impossible, determine whether you can imagine borders, separating or connecting devices in between, structures making their mutual exposure possible. These constructions may be smaller than the differences they bridge, forcing you to detail them. Determine their operational scale. Identify the design problems for each radius (see *Fig. 52*).

Searching form variables of a second order

By drawing any of these differences, you were forced to provide them with a form. Distinguishing the same difference, you could have chosen another form from the many possible forms. Built-up and green may have been be separated by a straight, curved or vague line (see *Fig. 53*). 'Vague' lines are discussed later. 'Straight' and 'curved' are already values allowing many intermediate values. 'Straight is a clear zero-point, 'curved' can always be more curved. Then 'form' may have a variable itself. By assigning form to the difference, however, you have added a second kind of difference (see *Fig. 51* 5 superimposed upon the kind of differences discussed so far (e.g. 'built-up'). That content 'takes' form. Moreover, without content (i.e. without a difference between black and white in *Fig. 53*) there is no form. Form thus produces a 'second-order variable'. Perhaps there are more variables of form that have yet to be distinguished.

Fig. 53 Straight, curved, gradient

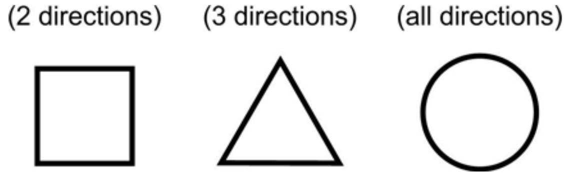


Fig. 54 Paralellogram, triangle, circle

Diversity of direction

If your drawing shows a first order difference into all directions, then you made a shape with a 'contour'. This contour itself requires at least two directions in order to make a difference between inside and outside. Alternatively, you could also have done it using three (triangle) or more directions (see *Fig. 54*). 'Contour' is another appearance of form. 'Direction' is apparently an important characteristic of contour. A contour has a direction and a difference perpendicular to that direction. This is implicitly supposed in *Fig. 53*, which shows only one arbitrary direction of difference. It is explicit, however, in *Fig. 54*, which shows all directions. If you take 'change of direction' as a variable, *Fig. 54* acquires a reverse sequence. The circle has only one change of direction at its contour, a triangle three and a parallelogram four. Which variable shall we take?

Simplicity

Although 'change of direction' seems more complex, it is more tangible in our daily experience. Perhaps 'direction' is not so simple a concept as we suppose. You need a standard direction (e.g. 'North') and a standard angle with which to define it. 'Change in direction', however, compares two directions by itself. You can talk about 'more and less' change in direction. It has practical consequences at different levels of scale. A ball is smoother than a box, safer for children and easier to use as a football. A roundabout requires less interaction with the steering wheel of your car. The steering wheel determines the change in direction, not the direction itself. A circle has a shorter length than any contour surrounding the same surface. A circular building, however, may require additional constructive efforts. A constructor prefers a minimum of directions, but I would prefer 'change of direction' as a variable of contour, or even better: 'adjacent difference of direction'. 'Change' supposes a movement along the contour. Moreover, 'change of direction' could then be used to indicate a change in the contour as a whole.

Form as a state of distribution

The form of a town seldom has a clear-cut boundary or contour. Its boundaries often have the character of a gradient, as shown in *Fig. 53*. The built-up area is dispersed differently across the area. Nevertheless, it still has something that you may call 'form', which is different from other towns. A gradient nevertheless shows an infinite number of intermediate values. You cannot name them all separately and use them in a lengthy legend.
The usual solution is to divide the values into classes of density, assigning each class a colour and a contour in the drawing, as altitude lines in a map. This solution, however, hides the true *form* within each class. The contours depend upon arbitrarily chosen class boundaries.
A better solution would be to draw dots at a size representing an actual quantity, such as the standard population (see *Fig. 11* on page 45) or the surface of built-up area (see *Fig. 15* on page 46). Understood as 'dispersion in space', 'form' has many advantages over 'contour', but you are accustomed to drawing lines. The dispersion of people in space thus also acquires a 'form' (see *Fig. 55* representing a surface of 300m^2 urban space/person in any dot of 100 000 or 10 000 inhabitants and *Fig. 56* 30m^2 floor space/person in dots of 1000 inhabitants). The dot-map representation can be used at any level of scale, and not only for people/surface as a variable. It can be used for other variables as well (e.g. built-up area, employees, capital, trees, parked cars). Statistical data obtain a dispersion in space, a form.

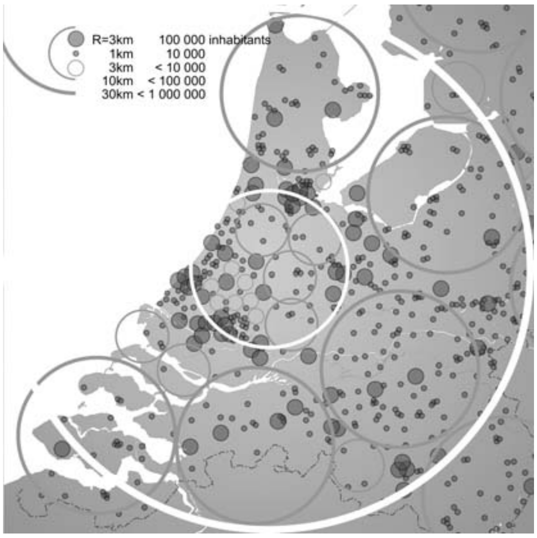


Fig. 55the Netherlands R={100, 30km}
10^5 and 10^4 inhabitants/dot
($300m^2$ urban space/inhabitant)

Fig. 56 The Hague R={10km, 3km}
10^3 inhabitants/dot
($30m^2$ floor space/inhabitant)

Diversity of distance

An old-fashioned printing pattern of different-sized dots at the same distance in a grid clearly proves that such a representation can show a form accurately (see *Fig. 57*).
It includes both sharp contours *and* gradients. The Dutch artist Peter Struycken used a representation with the same results by applying dots of the same size (see *Fig. 58*). This technique uses their mutual distance to determine the density (or, more precisely, the distribution) of dots. If you use dots to represent a quantity, a computer can count them, thus producing the density for any surface within chosen boundaries.

Dutch
stamps
<

>

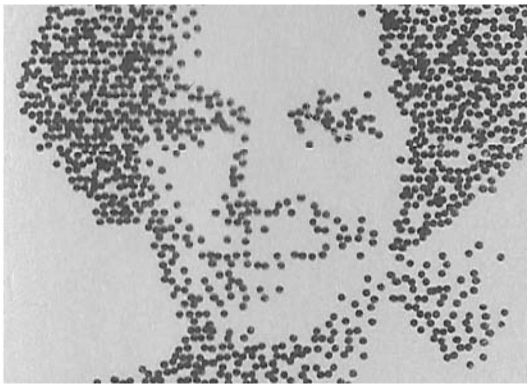


Fig. 57 Different size, same distance

Fig. 58 Same size, different distance[a]

Dot maps for research

In 1854, the famous physician John Snow used a dot map to find the cause of a cholera epidemic in London. He dotted the cases in a drawing (see *Fig. 59*) and discovered that they were concentrated around a water well. He then suspected this well as the cause of the disease. This discovery caused a revolution in medical thinking about epidemics and infection. It clearly shows the advantage of dot maps for empirical science as well.

[a] Peter Struycken

Fig. 59 Snow's map R=300m[a]

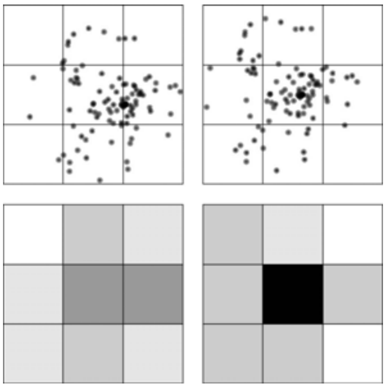


Fig. 60 Reductions in GIS

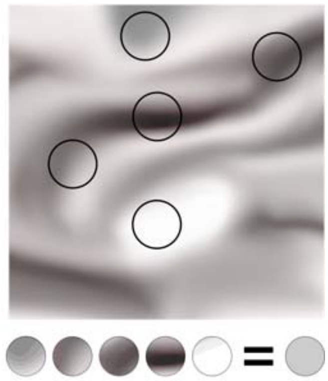


Fig. 61 Reducing gradients

When generalising such data in a GIS application, however, the grid may reduce the same dispersion in different ways (see *Fig. 60*). It depends on the location of the grid and the classes chosen. It hides the form. A higher resolution could reproduce the form (see *Fig. 57*), but this would requires precisely located data, and it would reduce the speed of calculation. Moreover, reduction into averages too large for distinction may cause gradients to become invisible (*Fig. 61*).

Dot maps for design

The use of dot maps for design and planning has great advantages. *Fig. 62* shows an example of four alternatives for 50 000 inhabitants, drawn in 50 added dots of actual size. This type of map is easy to draw and useful for traffic engineers, shop planners, ecologists and other specialists to evaluate a design concept in its first stage. Dot maps are a bridge between design and empirical data.

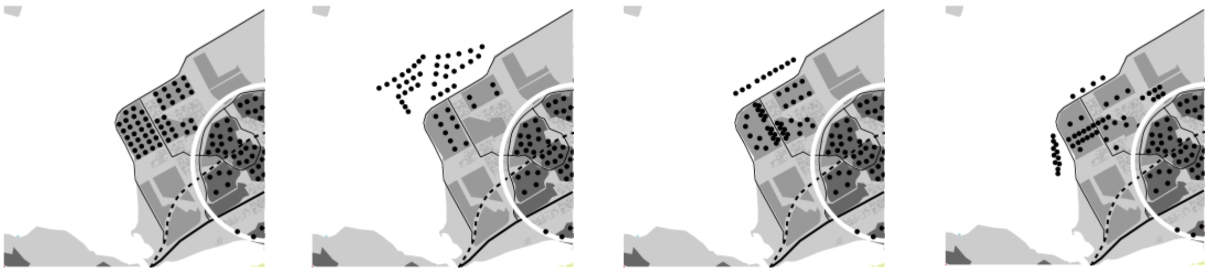


Fig. 62 Alternatives for 50 000 inhabitants in Almere R=3km, 10^3 inhabitants/dot[b]

Beyond the detailed data the plans of *Fig. 62* also have a compositinion with distinguished components. If you look at *Fig. 57* and *Fig. 58* at some distance, you can immediately distinguish a face, a neck, hair and background as *components* of a symmetric *composition* at a larger scale. At this scale, the same image still shows other differences.

[a] http://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak
[b] Jong (2001) Ecologische toetsing van drie visies op Almere Pampus (Zoetermeer) MESO

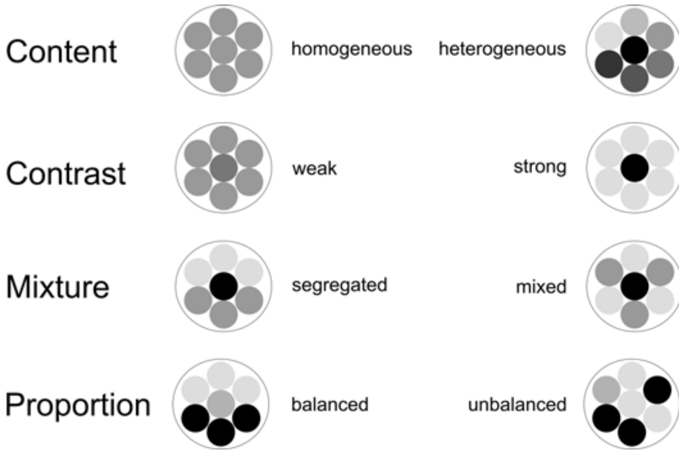


Fig. 63 Variables of composition

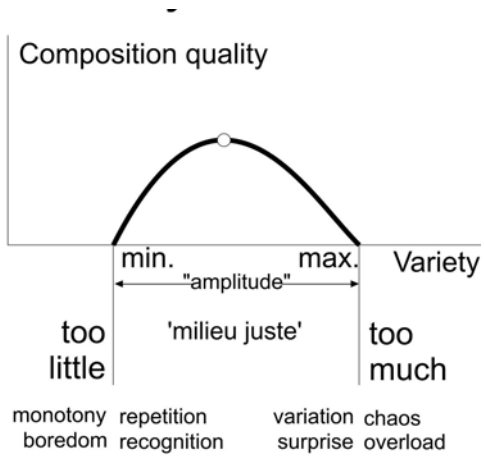


Fig. 64 Quality between recognition and surprise

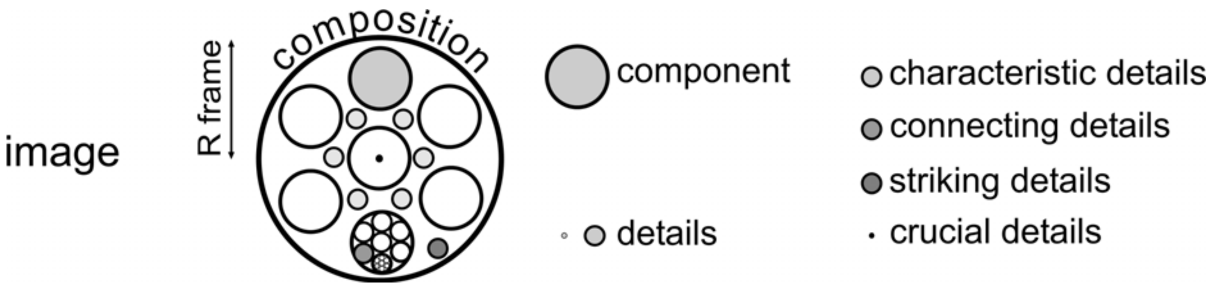
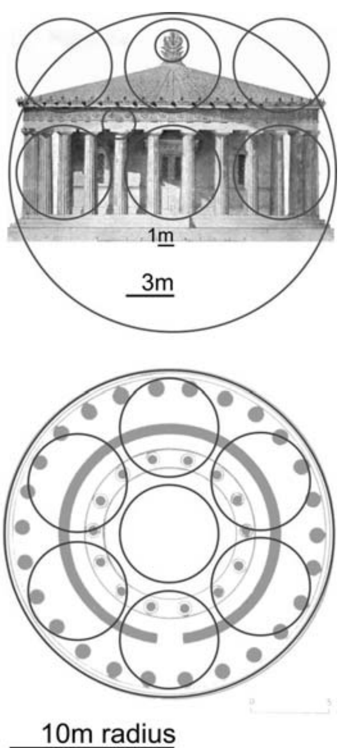
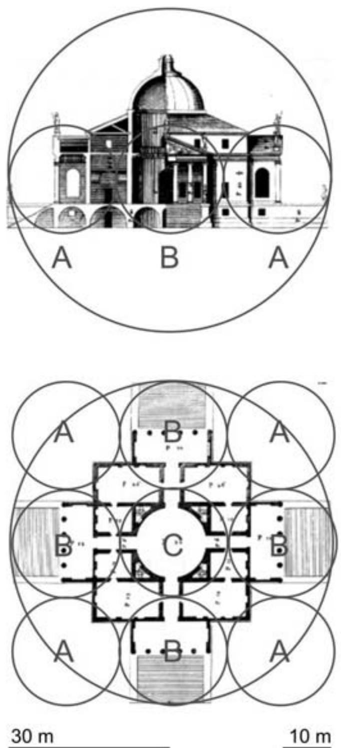


Fig. 65 Composition, components, details



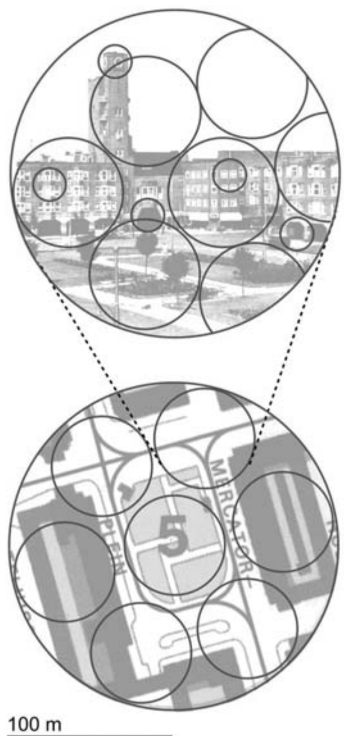
Tholos of Asklepios, Epidauros

Fig. 66 R=10m composition



Villa Rotonda (Capra) Palladio, Vicenza

Fig. 67 30m composition



Mercatorplein, Amsterdam

Fig. 68 100m composition

Diversity of composition
A composition may have a homogeneous or a heterogeneous content, components with weak or strong contrast, segregated or mixed mixture, or balanced or unbalanced proportions (see *Fig. 63*)). All of these variables contribute to its variety. Too little variety is boring, while too much variety gives a chaotic impression. Between these boundaries, the 'quality' of a composition is determined by a balance between recognition and surprise (see *Fig. 64*). In addition to the *components*, however, smaller details substantially contribute to a composition. They belong to the composition and relate it to a lower level of scale (see *Fig. 65*). You can distinguish four types of details:

1 *Characteristic* details showing repeating features *within* a component,
2 *Connecting* details transitional *between* components,
3 *Crucial* details with the same impact as a larger component,
4 *Striking* details, an accidental 'label', not really a part of the composition.

Compositions of different scale
You can recognise such components and details at any scale (see *Fig. 66 - Fig. 68*).These figures use non-realistic standard circles for components of different size and form in order to maintain a distinction between components and details in its legend of *Fig. 65*. They fit relatively well in *Fig. 66* and *Fig. 67*. On the other hand, *Fig. 68* shows how standard circles can also suggest smaller and larger 'real' components through their overlap or separation. The 'real' components often have vague boundaries with transitional zones. Different people will separate them differently. Any attempt to delineate them more precise in a drawing is unnecessary, however, if a standard circle shows their location and roughly their size, leaving some freedom of interpretation with regard to their boundaries.

Visual and real structure
Due to the structure of your eyes, your field of vision has a clear central focus and a vague outer boundary. With this field, a central component may be more clearly distinguished than peripheral ones are. Rapidly shifting your focus, you try to comprehend objects as compositions containing central and peripheral components and details. A painting with a clear frame helps to limit your attention. It separates the composition intended by the painter from a further context. If it is a large painting, you can look more closely in order to discover smaller compositions, thus framing them yourself. If you refer to a set of separations and connections as 'structure', the 'structure' of a 2D visual *composition* is something other than the structure of mechanical and functional connections and separations that constitute a 4D reality. If a 3D object remains stable in this changing reality, it offers you the possibility of obtaining infinite alternative and repeated views from different positions in order to *construct* a 3D image. In order to obtain 4D insight into the connections and separations that keep the observed components together, however, you will need even more impressions and even closer examination. At one time, you may have discovered that the scenery in a theatre has another construction than the same scenery outside the theatre. If you wish to restore old buildings, you may change their internal structure in order to preserve the external form. The same external *form* may thus have different *structures*. Environmental structure may thus differentiate through its own variables superimposed on its morphological diversification. This structural diversification may subsequently have independent variables of a third order.

Searching for structure variables of a third order
'Structure' is defined as the 'set of connections and separations stabilising a form'. You have repeatedly received equal impressions of a form so often that an independent external reality has become more than probable. Environments with an equal form may nonetheless have a different construction or structure. An image or a souvenir copy of the Statue of Liberty looks like the real one, although they clearly have a different structure (see *Fig. 69*).

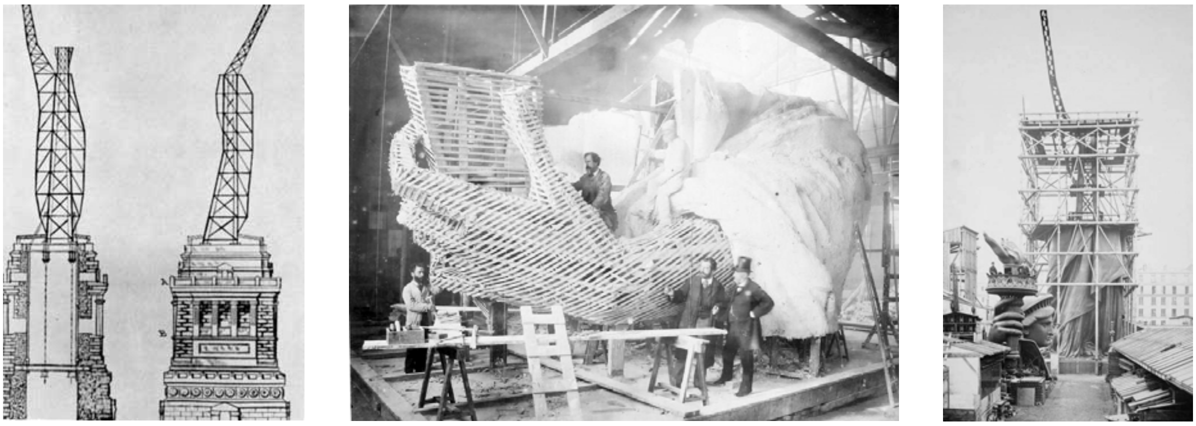


Fig. 69 The New York Statue of Liberty constructed in Paris 1884[a]

Any structure should have a distribution of its connections and separations in space, a form. It assumes ‘form’, but the external impression may have a different form and character. They may sometimes appear as *connecting* details in the impression of a composition, although they may *separate* in a mechanical sense. A column resists pressure; a wall resists energy flow. The components of a composition may be *separated*, but the structure may unveil that they are *connected* by internal details (e.g. stress cables or ventilation pipes).

Invisible mechanical connections and separations
The mechanical connections and separations may become materially visible, but they consist of invisible forces and flows. Engineers draw such forces and flows in schemes with a distribution in space in order to decide how to materialise them, even though they are invisible in the final appearance. The expected stress and pressure in a reinforced concrete beam, the core of its structure, have become invisible. ‘Structural’ architects accept the laws of forces and flows and try to make them visible, as in the Eiffel Tower and many bridges. Formalists primarily design compositions to be followed by the design of an appropriate structure, as in the case of the Statue of Liberty. Gustave Eiffel designed them both.

Structure at larger scale
Could you name *variables* of structure beyond those of form? Although pressure and stress, movement and stability may be their values at the scale of a building, what is ‘structure’ in larger environments? Which values do these variables have and how could you name their third-order variables of structure?

Direction paradox of structure
Roads and dikes indicate the existence of a set of connections and separations that you can call ‘structure’ at a larger scale as well. They are usually called ‘infrastructure’. A paradox emerges, however, when studying the effect of dikes and roads in different directions. Dikes are intended to *separate* water levels, but their tops are often used as a road. This reflects a *connection perpendicular to its separation*. Roads are intended to connect, although they separate perpendicular to that direction. Planning an urban highway is intended primarily to connect parts of the city. The separation they cause between districts on both sides may be concerned as a minor ‘side effect’ of the primary connection.

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[a] Eiffel(1885)*Framework of the statue*(Scientific American)52 24
http://archive.org/search.php?query=Scientific%20American%20June%201885
Bartholdi(1883)*Album des Travaux de Construction de la Statue Colossale de la Liberte destinee au Port de New-York*(Paris), http://2.bp.blogspot.com/-zoqEQfglacY/TqsyqVDzNGI/AAAAAAAAANE/dwD0xSzaYjI/s1600/li.PNG cited in:
Levine; Story(1957)*Statue Of Liberty National Monument Liberty Island, New York*(Washington, 1957) United States Department Of The Interior National Park Service Historical Handbook Series No. 11
http://archive.org/details/statueoflibertyn00levi

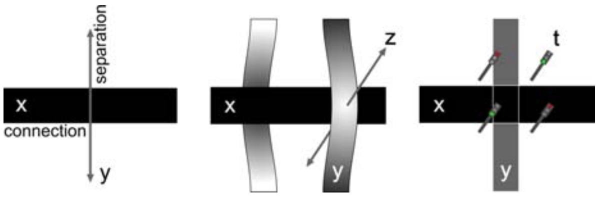

Fig. 70 Separation y $\perp$ x? separate in z or t!

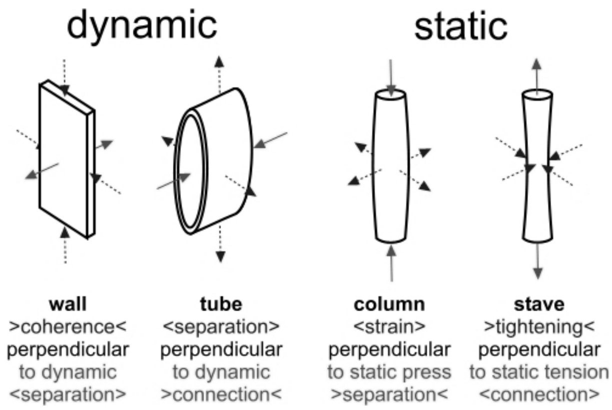

Fig. 71 Direction paradox in construction

It is a secondary problem at a smaller level of scale, to be solved next in the detailing process of design. Its solution may be to make tunnels or viaducts in order to restore some connection between the districts on both sides of the road. This is a vertical (z) separation intended to realise connections in two other directions (x and y, see *Fig. 70*). This solution, however, requires slopes on both sides, which cannot easily be crossed. These slopes cause serious separations and detours in the adjacent districts themselves. The designer can decide to separate in the fourth dimension (time) instead of the third: a crossing on the ground with traffic lights. Although this will cause delays, it will allow a periodic connection in both directions. You can observe a similar direction paradox at the scale of building construction (see *Fig. 71*):

- A wall *separates* if it is properly *connected* perpendicular to the direction of its separation.
- A tube connects only if it properly separates in the other directions.
- A column shows strain perpendicular to its separating function (enthasis).
- A stress-taking cable constricts perpendicular to its connecting function.

How could you find a one-dimensional variable for a 4D phenomenon? The direction paradox may extend beyond the directional limits of verbal expressions, logic and variables.

Verbal expressions assume one direction

The sentence ‘A road connects’ is direction sensitive. The *direction* in which it connects is a hidden assumption within the firm verbal expression. The sentence ‘A road connects and separates’ as appears to be a logical contradiction. A two-dimensional drawing allows this kind of contradictions: what is true in one direction (connection) may be false in another direction (separation). A drawing implicitly shows different directions. This assumes at least a plane. A drawing makes different inferences and conclusions possible at the same time, even if they are mutually contradictory. Verbal expressions are fundamentally one-dimensional, as is logic. A verbal, logical or mathematical inference has a strict sequence in one dimension: time. This sequence cannot always be changed without sacrificing its meaning. Its ‘side-roads’ must be neglected or distributed in footnotes, attachments, subsequent chapters or other references. Otherwise, the reader will ‘lose the way’.
Links in a website allow this kind of branched verbal communication more easily. Different readers can choose their own routes. The number of verbal routes from which to choose, however, is still more limited than in a drawing.

Weaving a picture by linear expressions is a weft without warp
A picture simulated in words must be reconstructed line-by-line, as a computer screen does with pixels. A verbal text describing an image completely with its sequences in any direction of its surface would fill many volumes with many notes, clarifying attachments or references. A drawing is easier to make and easier to understand than the verbal descriptions of many linear routes and their crossing relations. A drawing, however, allows different interpretations. At one point, a verbal description may be divided into different inferences: 'In this direction, the road connects, and in that direction, it separates'. This only multiplies the verbal effort at every point in the inference, however, and it requires many explanations of the mutual contradictions. 'To ex-plain' literally means 'to make it plane'. A picture may be worth more than a thousand words, but which words are they?

Drawings contain more directions than one line of inference
The direction of reading a drawing is not prescribed. A drawing may thus be interpreted differently by different people. That is a substantial difference between the mainly linear, possibly branched verbal language of scientists and the largely pictorial language of designers. Designers do have at least two spatial dimensions available in their drawings (apart from the time dimension). In addition, a location-bound picture does not generalise as words do. Nouns and verbs assume general concepts that are applicable in different contexts. Their hidden assumptions or generalisations are not always explicit. The pixels of a photograph do not assume anything other than a one-to-one spectral relation within an assumed reality. A legend next to a drawing is something in between; it is the vocabulary of the drawing. Nevertheless, the generalised legend units are distributed two-dimensionally in the drawing, showing at once many spatial relations in to explore in different directions.

Studying environmental structure
If you restrict your study of structure to possibilities of movement, you may find third-order variables of structure useful. By definition, movement is linear in space. It has a one-dimensional sequence that can be described in sentences, as in a travel log. For example, 'I drove in a dark tunnel, and I came out into a sunny open, flat landscape'. This sentence reveals something about the structure of the tunnel and the landscape. 'Openness' and 'seclusion' may be values to be studied at different levels of scale. Intermediate values may be found if you distinguish 'seclusion' in different directions.

Selectors
A box is closed in six directions. If you open its lid, you obtain something similar to a cup. A cup is closed in five directions. If you remove its bottom, you obtain a tube, which is still closed in four directions. A gutter, a corner and a plane are open in three, two and one direction, respectively. Moreover, you can subdivide these fundamental elements of structure by degrees of openness or seclusion. A window is open to light but closed to other movements. It 'selects' like a sieve. It is a 'selector'. Boxes, cups, tubes, gutters, corners or planes also select possibilities of movement. Any element of structure may thus be called a 'selector'. A door allows the user to select the moment of movement. It is similar to a valve.

A variable of structure

Perhaps you could identify the variable between 'open' and 'closed' as 'selection'. Is there a zero point for this variable? Could a box be more closed than any given level of 'seclusion'. Could you imagine an open space that is more 'open' than a given level of 'openness'? An infinite vacuum may provide a zero point of selection. At the other extreme, however, even a criminal hiding in a bunker that is closed on all sides could be caught. Dictators hiding in wells or sewage tubes can be found. The degree of accessibility may thus provide infinite values of 'seclusion'. We have thus found a variable. Perhaps there are more. Regardless of the variables that you may find for structural diversification, two environments with the same content, form and structure may still be *used* and *intended* differently. Variables of even higher order may be required to cover environmental diversification.

Searching variables of any order

The purpose of the previous exercise was merely to show the methodological possibilities and limits of a kind of study by design. There may be many more appropriate variables and kinds of study to cover environmental diversification in all of its appearances. No single study can explore all of them. However, one example of this kind of study related to empirical research and policy is sufficient to prove its possibility. It can be conducted at different levels of scale and by different orders of variables. It may be clear that different levels of scale require the selection of different variables. The different orders of variables that assume each other may be more difficult to understand (see *Fig. 72*). They condition or assume each other in an inescapable sequence for design *and* research. You cannot distinguish any intention without referring to functions. You cannot distinguish functions without making assumptions about the structure in which they perform, and the process continues.

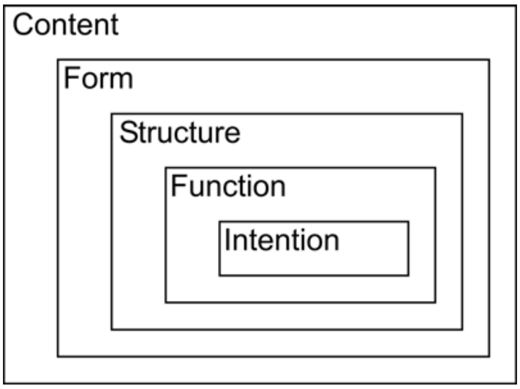

Fig. 72 Orders

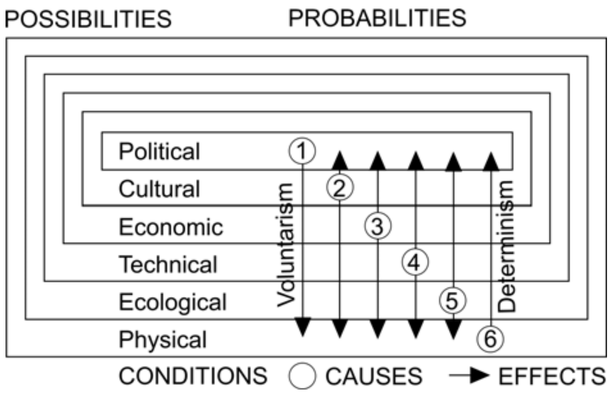

Fig. 73 Layers

There is no difference between design and research with regard to distinguishing these orders of variables. Their difference is the search for possibilities or probabilities in any order, determined by conditions or causes (see *Fig. 73*) in different layers. Empirical research is divided into science and the humanities. Science may be further divided into the specialisations of physics, biology (ecology, if the focus is on environment) and technology (or the history thereof). The humanities include specialisations with an economic, cultural or managerial focus. *Fig. 73* presents that rough subdivision, but it shows more as well. It also shows that there is a *conditional* order to these specialisations, focusing on different *layers* of the environment. In addition, there are different opinions about where causes should be found if some effect were to produce an external problem to be studied. These opinions range from voluntarism (1) into determinism (6). Although this debate has a philosophical character, a designer should be aware of its possibility.

2.8 Aims and problems expressible in words

Means-directed study

The all-encompassing objectives of the first chapter have been limited in the second. Becoming aware of the problems that a means-directed study may encounter requires an exploration of its limits. This forces the designer to address the details of these limits in advance. In doing so, the designer determines what could be studied at all. The process provides the study with an intention, a function, a structure, a form and even some content to be elaborated. It is remarkable that this kind of means-directed study apparently requires such an exercise of extending and bounding of the subject before you can properly formulate what its aims and problems actually *can* be. Part of the invention must be performed before you can do so. Only this could provide sufficient insight to formulate the aims and the field of problems listed below.

The external problem and aim

The proposed external problem is as follows: Design practice may lack instruments.
The aims of the study are therefore as follows:

1. To *find* a trans-disciplinary vocabulary by which the concept of environmental diversification can be handled and most fruitfully developed further in design, science and policy
2. To *create* a set of variables and a set of hypotheses about spatial relations suitable to elaboration and evaluation by research, and suitable to design and the realisation of any possible kinds of environmental diversification

The internal field of problems, the questions addressed

The field of problems this study may encounter can be approached by the following questions:

As a consequence of the first aim:

a. Which kinds of possible diversity can be distinguished at different levels of scale?
b. How can they be described in categories that are useful in design, science and policy?
c. What is their use for humans, society and nature?
d. How could they be developed, designed and realised?

As a consequence of the second aim:

e. Is it possible to express the categories mentioned in b as variables?
f. Are they scale sensitive and, if so, how scale sensitive are they?
g. If they are scale sensitive, how do the different levels of scale interfere?
h. Could they take on extreme values or a ‘zero’ starting point without previous values?
i. Which rationale could the sequence of their values obtain?
j. How can these values be dispersed in space beyond this sequence?
k. How do they interfere if they are not paired according to their rational sequence?
l. Are there different kinds of interference?
m. Which kinds of interference may be useful?
n. Does the diversity of opinions about this use constitute an environmental variable