1 Three language games

1.1 Modes of reason

Action, reflection, decision

The world of our experience has been divided into modes of action, reflection and decision. You cannot easily switch from one into the other. Different language games are now required: different distinctions, a different logic, a different kind of communication. Despite the fundamental and necessary unity of the individual, you have unquestioningly accepted that these tasks are divided in time, in space and even between people. There is a time to act, a time to reflect and a time to decide. There are places of action, reflection and decision-making. There are artisans, scholars and managers. And, these modes are divided at many levels of scale. There are workshops, instruction rooms and decision rooms. There are factories, schools and offices. Any mediaeval town had a market place, a church and a town hall. Any contemporary conurbation has areas for industry and shops, for culture and schools, for the offices of government and management.[a]

Lost awareness

Even though you can know, choose and realise more than ever before, you must wait until there is enough information, until it is decided, until the finances are guaranteed and until it is made. The intermediate time is filled up with specialised work in other projects for your employer or clients, in order to earn the money for your own projects, your household, your leisure or your enterprise. Money does not acquire value until it is spent in the realisation of your own projects; it is essentially a delay of payment. Its anonymous exchange dims your awareness of the other modes - and *their* further task divisions - assumed and supplied in anything you buy. You do not *practice* them, you do not *know* them and you did not *choose* any of them. You once chose your own specialisation and network.

Part in a sequence of actions

This is a consequence the unique human ability to oversee a range of actions only the first of which can be done immediately[b] and only the last will satisfy.
You have accepted the fact that once you have chosen, the action and the knowledge will be largely the territory of specialised other people or of self-evident facilities remaining from the past. You take them for granted. You have accepted that the situation in which you act is not a situation in which you can reflect or choose; it is either a situation that has been reflected and chosen for you or one upon which you have reflected and for which you have chosen in a remote past.

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[a] This 'trias urbanica' has been recognised by such authors as Brugmans and Peters, George, Jakubowski:
Brugmans; Peters(1910) *Oud-Nederlandse steden 1 en 2* (Leiden) Sijthoff
http://team.bk.tudelft.nl/Publications/2012/Literatuur/Brugmans(1911)1.pdf
http://team.bk.tudelft.nl/Publications/2012/Literatuur/Brugmans(1911)2.pdf
George(1966) *Geografie van de grootstad, het probleem van de moderne urbanisatie* (Utrecht / Antwerpen) Het Spectrum
Jakubowski(1975) *Basis en bovenbouw* (Nijmegen) Socialistiese Uitgeverij Nijmegen
[b] Harrison; Weiner;Tanner;Barnicot(1964) *Human Biology* (Oxford) The Clarendon Press

Communication between modes

If it is important to restore the unity of these modes, it is also important to recognise their separation. It is a crucial ambition of this study to restore the communication between technology, science and policy, as well as between design, research and decision-making. This distinction forces itself upon us in the failure of the communication between science and technology (i.e. knowing existing things and making new ones), understanding and artisanship. It forces itself upon us, when expertise and the power of decision, science and policy, expertise and management, go their separate ways, with all of the adverse or even fatal effects associated with such a situation. If this communication fails, decision-makers may choose impossible or past futures, designers may invent undesirable objects and scholars may discover useless facts or truisms.

Language games

To begin, it is important to understand the distinction between these modes and their different terminology. You cannot restore their unity before their distinction is clear. You cannot achieve this aim before the problem is understood. This problem emerges in any project, even if it is not recognised by the participants. Any project contains a projection into some future. The problem is thus that these three modes are oriented towards different futures. They acquire different perspectives in different social sectors. They become divided over different types of activities and professions, requiring different modes of thinking and communication. This reduces your reality in different categories (see *Fig. 1*). Wittgenstein referred to context-sensitive ways of talking and writing as 'language games'[a]. These games may use the same terms to refer to different things or different names for the same things. Their vocabulary and meaning are dependent upon their context.

Language games	**Being able**	**Reflecting**	**Choosing**
Futures	possible	probable	desirable
Sectors	technique	science	management
Activities	design	research	policy
Modes	conditional	causal	normative
Reductions as to			
character	legend	variables	agenda
location or time	tolerances	relations	appointments

Fig. 1 Three language games to be covered in any project

Probable, possible and desirable futures

If you accept that any *probable* future is *possible* by definition, but not the reverse, then the probable futures are a subset of possible futures (see *Fig. 2*). If so, there should also be *improbable* possibilities. Because they are not probable, you cannot expect or predict them in a *causal* way. You must *design* such possibilities by shaping their technical *conditions*. The mode of conditional thinking differs from the mode of expecting the effects of causes (see *Fig. 3*). A house does not *cause* a household; it makes many households *possible*. Deciding whether you also *want* these households, is yet a different mode. Many of the desirable futures are not possible. Forget them. Other desirable futures may be probable. Do not take action. You can expect them to happen without action. Take action only if there are probable futures that you do not want (problems) or if there are improbable possibilities that you would like instead (Aims, see *Fig. 2*).

[a] Wittgenstein, L. (1953) *Philosophical Investigations* (Malden, Oxford, Victoria 2001) Blackwell Publishers

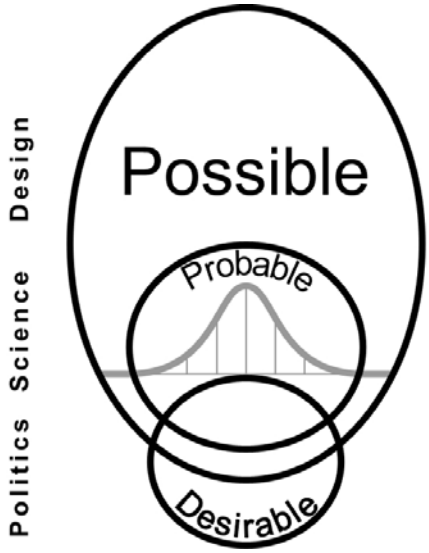

Fig. 2 Possible, probable, and desirable futures

Fields of problems and aims

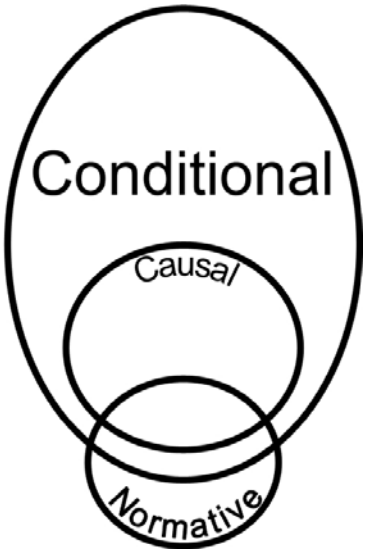

Fig. 3 Modes of reason

Science and humanities as a design

If you associate a conditional way of thinking with design and causation with science and humanities (see *Fig. 3*), you may conclude that any cause is a condition for something to happen, but not the other way around. Conditions do not *cause* events; they only make them *possible*. You may even draw a conclusion that empirical researchers are not very likely to accept. You may conclude that science and the humanities constitute a design in and of themselves, and not the other way around. If they are a subset of design, then design cannot be fully covered by an empirical language. If this is true how should you cope with the improbable possibilities that remain for design in a scholarly way? Which language and logic are needed? If you are able to develop such a logic of technical conditions, it should also be valid for any causation. Causes *suppose* conditions. This may be the key to a common vocabulary and language. If you are not interested in impossible desirable futures, then it could also be a vocabulary and language suitable for politics and decision-making.

Priorities

My first priority is to be understandable and useful for spatial design and technology. The forum for this first priority is the community of spatial designers. They do not search for empirical *probabilities* or even *truths*, but for a larger set of *possibilities*. If a design were to be only probable, it would be a prediction. If it is to be a design, it must also include improbable possibilities, which may become true by realisation. Only after realisation can they allow empirical evaluation of their observed impacts. Such evaluation can suggest probable effects for future designs in other contexts, but this is not the core of design. It is part of its business as probable futures are a part of what is possible (see *Fig. 2*).

The second priority in this study is to be understandable and useful for empirical research and theoretical study in science and the humanities. These fields search for *probabilities,* or even *truths*. This thesis, however, contains very few empirical data. It is intended as an exploration of the *kind* of data that designers continue to need from science and the humanities. It attempts to translate some of these questions into a design language that may be more understandable to researchers. A design is not a prediction. It is neither true or false. It is even not probable. It is a possibility and a proposal that may be desirable.

The third priority is to be understandable and useful for policy and decision-making, for government and management. These areas look for what is *desirable* at different levels of scale. They decide about designs as proposals. They must balance what is probable, but not desirable (problems). They must be able to imagine what is not probable, but desirable and possible (aims). Let me first elaborate these modes of reason separately in more detail.

1.2 Spatial design and technology

The relevance of spatial design

The aspiration to be useful in spatial design (including technology) raises the underlying question of why spatial design itself may be useful for humanity and for society. Many nice utilities, buildings and towns have been built without the preparation of professional designs beforehand, separated from their realisation. A professional spatial design thus supposes to add quality (including new possibilities). This supposition justifies its profession and its education. It leads to the question of what 'quality' means within the context of spatial design.

Spatial quality

One of the oldest known texts on architecture was written in Latin by Vitruvius some decades before Christ. In the second paragraph of Chapter 3, in the first book, the most cited combination of words to date appears almost innocently. It is a simple distinction of architectural qualities: firmitas, utilitas, venustas (strength, utility and grace[a]). I translated this well-known distinction into a form intended to be useful at levels of scale exceeding those of buildings upon the request of a land development company (Heidemij) at the end of the 20th century. My translation reads: 'Value for the future (durability, sustainability), value for use and value of the image'. This description of quality appeared in Dutch governmental plans and it was frequently cited. As did its predecessor from 1978 this thesis contains an earlier formulation as structural, functional and morphological quality at any level of scale. You may recognise this formulation in the distinctions contained in Chapters 5, 6 and 4. In these chapters, however, the sequence of form (4), structure (5) and function (6) is conditional. Studying their *diversification* (the simultaneous process of morphological, structural and functional diversification) made it necessary to change their sequence in a conditional way. Their meaning shifted slightly in the process. Let me first concentrate on the sequence and then on their diversification.

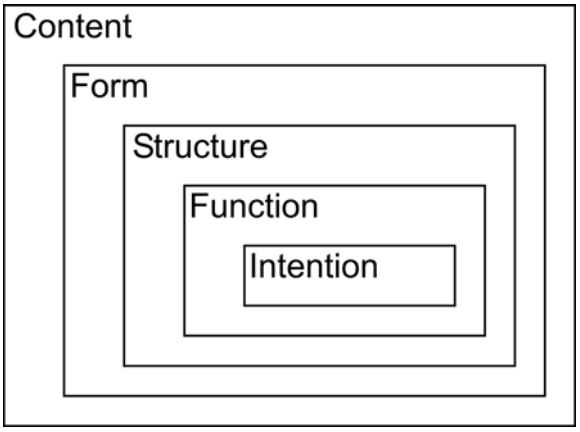

Fig. 4 Intention ⇓function ⇓structure ⇓form ⇓content

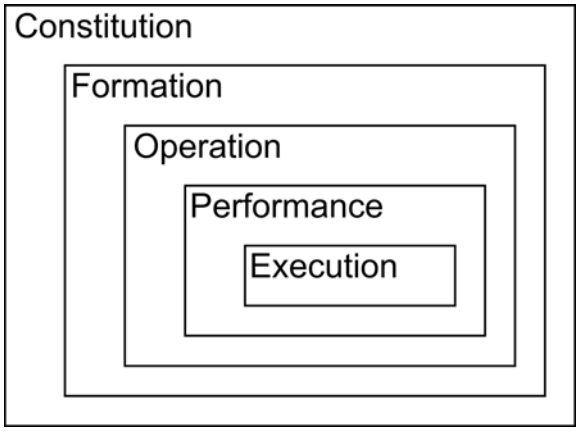

Fig. 5 Dynamic equivalents

A conditional sequence

The sequence of form, structure and function is not accidental. It is conditional within the mode of possibility. The latter *supposes* (as indicated by ⇓) the former (see *Fig. 4*[b]) if you

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[a] Vitruvius(27 B.C.) *De Architectura* (Cambridge Massachusetts 1983)Harvard University Press Loeb Classical Library series, Book I, Chapter III, Latin on page 34, with an English translation by Granger on page 35. Granger translates 'firmitas, utilitas, venustas' by 'strength, utility, grace'. On http://www.gutenberg.org/files/20239/20239-h/29239-h.htm Morgan translates them with 'durability, convenience, and beauty'.

[b] In *Fig. 4* and *Fig. 5* these categories are shown as Venn-diagrams. Instead of indicating subsets as a part of (⊂) sets with *true* conclusions, however, they represent *possibilities* that suppose (⇓) *technical* conditions. The diagrams are best understood as

accept a slight shift of meaning from the usual discussion of form and structure.
Any function (i.e. working) supposes a structure (i.e. a set of connections and separations). Any structure supposes a form (i.e. a dispersion in space). None of these aspects *causes* the latter making it *probable. Instead,* they *condition* the latter making it *possible*. Any structure supposes a form to be *operational,* and any function supposes a structure to be able to *perform* that function[a] (see *Fig. 5*). A function without a sufficiently stabilising structure may become useless in its first performance. Many utensils can be used only once, as their connections or separations are broken by that use. In order to be suitable for more frequent re-use, they require more durable connections and separations - they require more value for the future, more structure.

Structure ⇓ form

In its turn, a structure without a form does not have separate components to be connected. Even the words 'separation' and 'connection' do not have any imaginable meaning if they cannot be related to objects at different locations (a dispersion in space). 'Form' is supposed in any concept of 'structure' (i.e. the way *separate* components are *connected* together or conversely, the way *connected* components are *separated*, e.g. by a wall). Where components are composed into a composition (i.e. 'formation') they must suppose a form before we can recognise the difference between and the direction of their connections and separations (structure). It is for this reason that a chapter on morphological diversification should precede a chapter on structural diversification.

Structure and direction

Separation and connection require a spatial direction in order to determine their operation, even if that direction is variable. Separations perpendicular to connections are essential in any operation. For example, an electric wire requires isolation perpendicular to the direction of the afforded connection. If 'perpendicular' has no meaning, how are we to determine the operation of separation and connection?
This distinction between form and structure produces simple and operational definitions: dispersion in space (form) and the set of connections and separations (structure) stabilising the form.

Form, formation, composition

Function and structure do have dynamic equivalents (see *Fig. 5*): performance and operation. In this context the dynamic equivalent of 'form' is called 'formation', although 'composition' would fit as well. In the discussion below, 'composition' is used in this sense if demanded by the context. However, 'composition' has a dual meaning. You can 'compose' a form in the way painters or even musicians do (i.e. a distribution of components in space or time), but you can also 'compose' a content (as with the colours that painters choose before they distribute them on the canvas or the notes that musicians choose to distribute them over time in order to achieve a composition).

Form ⇓ content

Even a form supposes something that *takes* that form. There must be some content or matter *to have* that dispersion in space (*Fig. 4*). In designs this can be recognised in the form of a legend and its legend units (which are often implicit).

Intention ⇓ function ⇓ structure

At the other end of the range, the same function and its performance may be appreciated differently by different people in different contexts, each with specific desirabilities. Although function may suppose a structure, it *is* subsequently supposed in any human intention.

3D, imagining a third dimension.

[a] Tzonis, A. (1992) *Huts Ships and Bottleracks Design by Analogy for Architects* **IN** Cross, N.; Dorst, K.; Roozenburg, N. *Research in design thinking* (Delft) Faculty of Industrial Design Delft University of Technology the Netherlands Proceedings of a workshop meeting. Tzonis uses the terms 'operation' and 'performance' to refer to the action of structure and function.

Directions and dimensions

If you wish to study environmental diversification, you must study the diversity of contents, forms, structures, functions and intentions, as well as their development within that sequence (*Fig. 4*). Any of these aspects can be different in different directions (x, y, z), as well as within the fourth dimension of time (t). In time, their dynamic equivalents merely receive a different name (*Fig. 5*).

Quality is a function

The Vitruvian 'grace' thus becomes primarily a *function* for people, just as with any other 'utility'. It is apparently an important function, as it determines a substantial part of the price paid for buildings. But, if it is a function, then it must suppose something that performs that function. This should be a stripped concept of 'form', possibly stabilised by a structure. A form either pleases people or does not. Form is thus something other than its appreciation. Whatever 'form' may be without such a 'meaning', it precedes its function for people. Moreover, the same form can acquire different meanings for different people. Such functional diversification does not affect the form. This is a second argument with which to distinguish 'form' from any meaning *of* the form. For this reason, the hidden supposition of 'grace' (form) is separated and advanced in this analysis.

Visual quality ⇓ limited morphological diversity

The connection of form, structure and function to diversity and diversification is also not accidental. There is a relationship between visual quality and diversity, as noted by Birkhoff[a] and Bense[b]. The morphological quality of endless repetition is low. It is boring, and it looks cheap - but, the visual quality of excessive diversity is low as well. It is chaotic. Sensory quality falls somewhere in between, varying between surprise (by differences) and recognition (of equalities, see *Fig. 6*). The boundaries between excessive repetition and proper recognition and between acceptable surprise and chaos are present in any compositional work of art, be it painting, music or even culinary art.

Visual tolerance

This may be a special case of the well-known curve of ecological tolerance. For example, the chance of survival for plants on land depends upon the availability of water. An insufficient supply of water results in a small chance of survival just as an overabundance of water does. Every species chooses the right mid-point (mi-lieu) between drying out and drowning, as optimal for its survival. For some species, this optimum can be recognised along a slope, in which high is dry and low is wet. But, per species this tolerance can be studied for any environmental variable (e.g. the presence of chalk, phosphorus or nitrogen). It would thus make sense to take variation itself as an environmental variable for humans.

Quality is scale sensitive

The relationship with boundaries of acceptability on both sides (as depicted in *Fig. 6*) may exist at any level of scale, although in a different form at each level. For example, if you approach a building, you first may see the whole separated into some larger parts, as components of a composition, at the scale of the building as a whole. As you approach the building at a smaller distance, one part will cover the scope of your vision. Your eyes may search for a smaller second composition within that part, with smaller components (possibly known from other buildings), in order to make sense of what you are seeing.

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[a] Birkhoff(1933) *Aesthetic measure* (Cambridge, Mass.) Harvard University Press
[b] Bense(1954) *Aesthetica* (Stuttgart) Deutsche Verlags-Anstalt

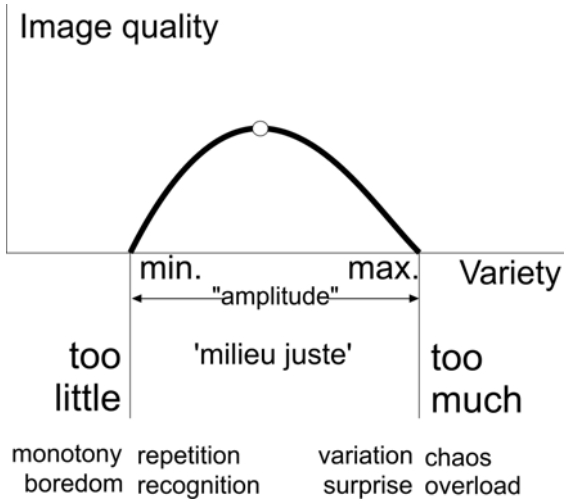

Fig. 6 Visual quality related to diversity

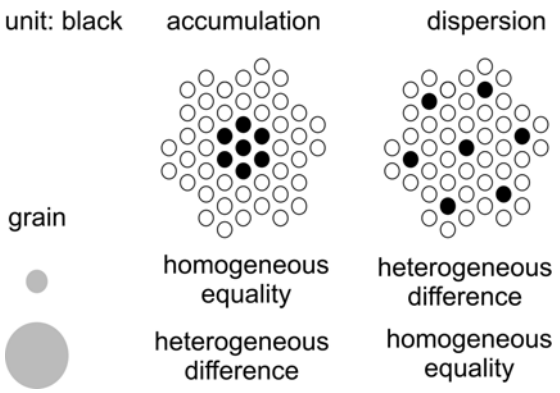

Fig. 7 Scale-paradox

Finally you may approach the entrance, with its even smaller components and details in the composition of the entrance, probably recognising elementary building materials. This crucial relationship between diversity and scale, as determined by the resolution of our senses had not yet been noticed by Birkhoff and Bense. At one level of scale, you observe differences, while you may recognise equalities at another level (scale-paradox, see *Fig. 7*). A scale difference of factor 3 transforms the observation into its opposite. If at different levels of scale a, b and c the variety (ranging from equality E into differnce D) may differ as $E_aD_bE_c$ or $D_aE_bD_c$. You may name these alternatives 'variety accords'.[a] The appreciation of diversity (see *Fig. 6*) at different levels of scale (see *Fig. 7*) may explain why disciplines may have opposite opinions about quality. Architects and urbanists may refer to different levels of scale. The innocent observer, however, will experience a pleasant alternation of surprise and recognition approaching a spatial object. Successive smaller compositions may offer arousal through surprising stimuli and rest through the lack of stimuli passing recognisable patterns.

Functional quality ⇓ limited morphological diversity

The balance of *Fig. 6* may apply to the visual quality of Vitruvian 'grace' as related to the diversity of form. We must then ask, however, whether it also counts for utilities other than 'grace'. For example, a flat ground in the open air offers no other functions than for reclining, sitting, standing and walking. A slope already offers the opportunity to sit and rest with some more comfort, to climb and to descend, or to have a narrower or wider view. A wall provides shade, an enclosure safety and a house with rooms affords a multitude of possible functions. They represent an increasing morphological diversity as a condition for an increasing number of uses and choices (functional diversity). Potential function may thus be related to diversity. Any function requires at least one difference. In the example, it is the simple difference between ground and air. This is the lower limit of diversity. Is there an upper limit as well? In other words, is there a value of diversity at which a function starts to fail? Answering this question requires a closer look at 'structure', which lies between form and function; it is often invisible, but it apparently conditions the functions other than 'grace' more directly than form does.

[a] Ravesloot;Apon;Boelman(2005) *Aesthetics in urban design seen from the perspective of sustainability* (CostC12EU) TaylorFrancis, this article describes an application of variety accords in:
Jong; Ravesloot(1995) *Beeldkwaliteitsplan Stadsdeel 'De Baarsjes' Amsterdam*. (Zoetermeer) assignment Stadsdeel De Baarsjes Amsterdam to MESO

Function ⇓ structure

The relation between function and structure depends on scale. At a certain level of scale, a structure may have an external function. This function has no meaning, however, without a concept of an even larger external structure in which it functions through connections and separations at *that* level. For example, if you ask somebody, “What is your function?” then (s)he may answer, “Director”. To know what the function actually is, you must ask further, “Director of what?”. It makes a difference whether the answer is “a one person household” or “a company”. ‘Function’ thus supposes a larger structure of which it is a part. Within this larger structure, a function may have connections and separations in different directions. At the beginning of this paragraph, however, we stated that, at a certain level of scale, a structure may have an *external* function. The resulting *internal* structure is something other than the larger *external* structure. It refers to a smaller level of scale. Any element of that smaller structure may again have a specific ‘function’ within that structure and this ‘function’ is definitely something other than the function of the smaller structure in a larger whole. Structure and function are thus scale-sensitive, as I previously concluded for visual functions. They have no proper meaning without reference to a level of scale.

Structural quality ⇓ at least some morphological diversity

This still does not answer the question of whether any function other than ‘grace’ may have an upper limit in the diversity of its morphological appearance. It does, however, allow us to shift into the question of whether any invisible *‘structure’* has a relationship to morphological diversity, and whether this relationship has lower and upper limits. For example, in building mechanics *size* counts. If you make a beam too thin according to what it has to bear, the structure will fail. On the other hand, it will also fail if you make it too thick in relation to its span as a consequence of its own weight. In larger constructions (e.g. bridges) you can take away the parts that do not contribute to the function of spanning. This saves own weight and it results in a kind of parabolic form well-known from many bridges. It divides the functions of its elements into connecting (stress-taking) and separating (pressure-resisting) components. It visualises the structure that is already present, but hidden within the beam. Incidentally, in the stripped definition of form (pure dispersion in space), this form may be invisibly present, hidden within a beam. Form can thus also be independent of human vision or touch and, consequently, from meaning. It may be invisible, but it can be visualised in a drawing. Anyhow, you can conclude that structure supposes some morphological diversity.

Structure ⇓ form

At this point, I leave aside the question of whether this is the case in other fields (e.g. the physics of temperature transition in a window) or at other levels of scale (e.g. the structure of a landscape or its infrastructure of connections and separations). One example is sufficient to prove the *possibility* of a relationship between morphological diversity and structure. The possibility of *not* having such a relationship, however, requires at least one example as well. I have not yet to find one. If someone claims to have in mind a structure a structure without a form, you could ask this person to explain that structure. (S)he would then take a pencil and a piece of paper and draw objects connected to each other in various ways by lines. You could then ask “Are you not drawing a form now?”. The answer would likely be “Yes, but the points and lines could be changed in size, and that would change the form. Regardless of its form, the structure remains the same”. This would be precisely what you wanted to hear, as you could now finish the discussion by saying “That is even worse for your argument, because it covers an entire *set* of forms!”. It merely proves that the same structure may have many forms. It does not matter which form, but it must have a form in order to be operational. It supposes form. Structure ⇓ form. Any time you want to express or explain it you must give it one of these forms. Incidentally, explain (i.e. ex-plain) something is litterally to distribute it in a plain. Even if we imagine an abstract structure of separations and connections, this structure supposes the directions of these separations and connections, as well as some distribution in space. Even if it is topological, it supposes form.

Structural quality ⇓ an upper limit of morphological diversity

By concluding that there is a conditional relationship between form and structure, the question of whether any higher degree of morphological diversity has *limits* for the proper operation of a structure remains to be answered. The lower limit is clear: you need at least two different objects separated in space or time in order to connect them. However, suppose that there are x different objects that can be connected or separated in x^x ways. If you choose one way to connect them, there would still be numerous possible patterns for the same structure. This kind of morphological diversity thus does not influence the structure unless you take the total length of the required connections into account. This may influence its operation. If you increase the *number* of different objects x, however, the number of differences would increase as well, and even more with x^x, which would increase another kind of morphological diversity. If all objects need some kind of connection within the structure, then a structure will be more diverse according to the increased morphological diversity. This implies a relationship between morphological diversity and structural diversity as we have already established. This still does not answer the question of whether there is an upper limit. A limit appears as soon as the connections and separations themselves need space. For example, if all dwellings in a neighbourhood should be connected to the public infrastructure, you cannot add dwellings by building them on the surface of the road. If space is limited (as it is in any spatial design), there will inevitably be a point at which the increasing number of objects cannot be connected or even separated. This point should be the morphological upper limit for the proper operation of the structure for which we were searching.

Independent structural diversity

This inference shows something else as well. Until now, we have limited our discussion to the influence of *morphological* diversity and diversification. The chapter titles in this study, however, also mention *structural* and *functional* diversification. Do these diversifications then have their own kind of diversity that is not covered by the underlying morphological diversity? For example, the structure of roads is largely characterized by a hierarchy. On average, every third residential street may be a neighbourhood road. Every third neighbourhood road may be a district road and so on, with urban, regional, national and continental highways. Moreover, there are networks for drinking water, sewage, data transmission and other matters. It is not difficult to understand what is meant by structural diversification or to understand that such diversification is likely to be limited given that any structure requires space. *Functional* diversification beyond its morphological grounds is more complicated, however, as it allows creative humans to enter the scene.

Independent functional diversity

Without a doubt, a wide diversity of functions remains possible, even independent of the underlying morphological diversity. The same room can accommodate many functions. Nevertheless, is there some upper and lower limit to its multi-functionality? For example, consider different types of pocketknives. An increasing number of functions (e.g. screwdrivers, awls, bottle-openers, corkscrews and even tongs) can be added to the original knife. At a certain point, however, the knife can become difficult to handle. Comprises in construction reduce the quality of the knife, the functions hamper each other and the knife no longer fits in your pocket. If you were to have only the blade, however, you would not be able to handle it either, and it would destroy your pocket without an additional function of coverage. Function may thus also have limits of multi-functionality – limits of a potential diversity of use. Too many or too few potential functions combined do disturb an effective use. In such cases, there may be an upper and lower limit of multi-functionality. This is not the place to elaborate the further complications of functional diversity and diversification. Its meaning in science and humanities is addressed in the next section and in Chapter 6. At this point, I present several preliminary conclusions about the intended relevance of this study for spatial design and technology.

Relevance for design and technology

Functional diversity has lower and upper limits. Potential functions must remain operational during their use and until a subsequent performance. They need a stabilising structure, without which they cannot be relied upon when making plans and focusing activities. This does not necessarily negate the importance of temporary opportunities. Such opportunities are a source of innovation. Nevertheless, there should be a balance between that which changes and that which remains the same within your environment. There should be a stabilising structure upon which you can rely, but it should leave possibilities for change, unexpected opportunities, affordances that may surprise and challenge. This is structural differentiation, which has its own upper and lower limits of economical technology. But, what if nobody is *aware* of these affordances? What if nobody is attracted by them? Morphological diversity on its own is a primary condition for distinctive awareness. A certain amount of repetition, however, is a secondary condition. Repetition enables recognition. Somewhere between recognition and surprise, the affect of attraction (i.e. ‘grace’) may appear. The diversity of form also has lower and upper limits. In addition to spatial repetition, this discussion concerns repetition in time (i.e. a presence in memory). This study attempts to extend the available means of designing to achieve appropriate morphological, structural and functional diversity at different levels of scale and their development (diversification).

1.3 Empirical science and the humanities

Limitation shows the master

Empirical researchers from specialised sciences and the humanities usually do not appreciate this kind of all-embracing reasoning about design or discussion of in terms of possibilities. They will say to you, 'Limitation shows the master! What is the problem you want to solve, your aim, your hypothesis, your theory? What are then the research questions to be answered, how are you going to answer them, what is your method? What are your starting points, your references, your variables. What is your data set, how do you collect the data, how reliable are they? How are you going to report the results?' I will try to answer some of these common questions in Chapter 2, because they make a study accessible for critique, and this is a crucial scientific criterion, even in the perspective of possibility.

Completeness of view

Yet another scientific criterion, however, has nearly been forgotten in contemporary science and the humanities since Descartes. It is contradictory with the limitations referenced above. This criterion concerns the requirement of completeness. The supposition that a synthesis of specialisations will ultimately cover possible realities does not hold. Although it may be an unattainable ideal, an architect neglecting the front-door or the kitchen of a house – thus 'showing the master' by limitation – will not easily get new assignments. You cannot suppose the rest to be the same ('ceteris paribus'), as the context always differs in spatial design. In environmental design, you are not faced with a single, well-defined problem, but with a field of connected problems. There is no single aim, but a field of aims represented by the many stakeholders and specialists involved. You cannot neglect any of them. Your hypothesis is the design itself, and this is precisely what requires the major effort.

Possibility search has other limitations than research

The limitations through which designers show their mastery may differ from those faced by researchers. First, designers work within a highly specified limitation of scale, even if the design has yet to be made. The largest and smallest relevant measure of the intended object limits the study substantially in space and time. Second, the variables to be taken into account are limited by their relevance according to that scale. The rest is context, which is not limited by scale, but by the administrative, cultural, economic, technical, ecological and spatial effects that must be taken into account, whether intended or not. This context may produce a verbally limited program of requirements, but that is not the whole story. The location limits the design project in its form, structure, function and political intention, including the limited possibility of changing them. Other important limitations in design include the experience, the portfolio, the repertoire and the references of the designer. These aspects are more important for determining whether the person fits the assignment than are the limitations faced by researchers. The scientific relevance of this study may thus lie in the fact that these limitations, and the variables involved, receive more attention in science and the humanities. If this is the case, I must explain their meaning in more detail and discuss how empirical research could help to gain a better grasp on them.

Probability ⇓ possibility

The requirement of completeness comes into conflict with the practical requirement of limitation if that limitation forces us to neglect relevant contextual factors. In empirical research, contextual factors are often neglected due to a lack of data. They are replaced by a ceteris paribus assumption ('all other things being equal'). In a spatial design, however, the context is never the same. Moreover, if the design has yet to be made, this ever-changing context is the only thing there is. The object itself does not yet exist. To an empirical researcher, this is bizarre. How can you study something that does not exist? For a designer starting a job, there is only an administrative, a managerial, a cultural, an economic, a technical, an ecological and a spatial context. Although the context may provide a program of requirements, it is based largely on earlier empirical *ceteris paribus* results from other

contexts. Furthermore, it can still be changed by sketching other possibilities that take advantage of unique local characteristics. Designers thus complain about the generalising character of empirical research and its lack of context-sensitivity: 'That may be true on the average, but not in the specific context of this project!'

The integration of specialisations by design

Any design project of appreciable size involves many stakeholders and specialists from the administrative, managerial, cultural, economic, technical, ecological and spatial contexts. A designer is asked to capture all of their claims and programmes in a single spatial concept. This concept is a hypothesis, which is subjected to preliminary testing by the accidentally composed team of specialists representing the contextual sectors mentioned above. They may have conflicting overlaps and unavoidable gaps. Even the elaboration of the concept into a more detailed design is still a hypothesis. Its hypothetical quality cannot be definitively falsified until it has been realised. Instead of facing a single problem to be expressed in a simple problem statement, therefore, a designer faces a *field* of problems to be balanced and 'solved' in the concept. This field is difficult to express in a one-dimensional verbal or mathematical language. Expressed in this way, these problems seem vague and full of loose ends. You may immediately recognise them in a drawing, however, where every direction tells a different – and sometimes opposite – story. This type of expression is another language, and it is not very convincing in science and the humanities. It is not a language of true and false. It is a language of possible and impossible. It explores the possibilities of matter in multi-dimensional space. It is a weaving of loose threads often spun by earlier scientific efforts. It often loosens the thread of these stories outside the actual weaving, as there are so many threads to be woven. Although it may be incoherent within the line of a scientific inference, it finds its coherence in the other directions provided by space.

Gaps and overlaps in the weaving of specialisations

Science and the humanities have been subdivided into an ever-increasing number of specialisations. The tacitly shared supposition is that they once will ultimately fit together to cover the whole of that which can be known. Any specialisation with its own peer-reviewed journal hesitates to enter the territory of colleagues from other specialisations. Their territories overlap nevertheless, and they leave gaps. The overlaps are hidden by the jargon that makes a specialisation inaccessible to other specialists, as well as to the innocent people who must pay for their efforts. The same things seem different only because they are named differently. A lack of overview prevents the gaps from being fully recognised. Who has had an overview since the *uomo universale* of the Renaissance? The more you think you know, the more gaps you discover.

Introducing other variables

Given the points discussed above, what could this primarily design-related study contribute to science and the humanities? First, it may draw attention to some still 'vague' variables that have thus far not been recognised as accessible to science and the humanities (see Chapter 3). It attempts to make them more explicit in relation to scale. Variables are one-dimensional by nature. They belong to the linear language of science, spinning an unbroken line of thought, ceteris paribus avoiding the side-roads. This weft misses the cross-roads of a warp as they are inevitable in designs represented in drawings. The missing threads of 'vague' variables may fill gaps in the weaving. They may bridge gaps that designers are accustomed to filling with drawings and vague verbal justifications. However, designers do not primarily think in variables. They think in discrete values and in legend units dispersed in their drawings, which acquire local connections and synergy. However, there may be unused values in the range of values composing a variable. This could enrich the legend of the drawing through the inclusion of intermediate or external values. The interpolation and extrapolation of empirical values may thus open unexpected possibilities for design. Raising awareness with regard to this possibility may pose a scientific challenge. On the other hand, there may be loose values applied in design that cannot be captured within the logical

sequence of a variable. How should we cope with them in a scientific manner? This question is inherent in the broader question of how to cope with diversity at all. Science searches for generalisations, equalities and equations that are valid in different contexts. Design searches for differences that may be overlooked or that may become possible. How should we cope with *possible* diversity? This question continues to bother me. I do not pretend to answer it in this study. It could even be that the inconceivable diversity of nature and of the possibilities for design will ultimately remain inaccessible to science.

Elusive form

The dispersion of values in a drawing (as expressed in the legend), seldom obeys the sequence of these values as they would be ordered in a theoretical variable. They largely appear as loose values scattered in space. Their harmonious or contrasting relation to adjacent elements is full of effects that are difficult to describe. The scientific or mathematical description of possible dispersions has been attempted in geography[a] and ecology,[b] but it it has yet to be resolved sufficiently. There is the problem of form and shape, which is often neglected in scientific approaches. For example, the essential form of a piston fitting into a cylinder has not yet been represented in the thermodynamic formulas that describe the processes that take place within a steam engine or a petrol engine. The Wankel engine could not be derived from thermodynamics. It could only be described after its invention. The combinatoric explosion of possibilities for distributing different materials in space remains a challenge for scientific description. This is painfully obvious in the comparison and analysis of designs. The solution certainly requires the articulation of scale. This may be one important suggestion of this study. It is only the very beginning, however, of a scientific approach to morphological differentiation.

Scale and resolution

Even a weaving will reveal gaps if you look at it closely. If the gaps of a gridiron are small enough to walk upon, however, should this matter for design? Any object of design has a cross-section with its largest measure. The scale of this object may be expressed most simply by the radius R of the smallest circle or globe circumscribing the object (its 'frame'). Less recognised, however, is the smallest measure taken into account by a designer. An architect need not take every molecule of the object into consideration. There is also a lower limit. For building design, this limit is the building material (e.g. a brick or a beam). Its scale may be expressed most simply by the radius r of the largest circle or globe it can contain ('grain'). Smaller gaps of knowledge need not be filled in order to make a proper design at the level of a building. The 'resolution' of the design is thus determined by r/R. Resolutions of 1/10, 1/100 or 1/1000 refer to a rough sketch, a proper drawing or a blue print showing all details, respectively. They are the spatial limitations of design thinking. There are similar limitations in time.

Opposite conclusions possible at a subsequent level of scale

The limitations in scope and resolution that are described above are common to all reasoning. Even scientific disciplines may have resolutions that are determined by the outer and inner limits of their scope. For example, it may be possible to sort the various ecological approaches (e.g. landscape ecology, systems ecology, syn-ecology, aut-ecology or chaos ecology) according to their scale of interest and resolution.[c] What may be true at one level of scale may be false at another level (scale paradox, see *Fig. 7*). For example, if a small town of R=1km grows to R=3km, it may acquire a new city centre serving the surrounding districts R=3km. The shops of the district centres R=1km may decline in competition with the main centre, but the smaller R=300m neighbourhood shops will receive new opportunities. The

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[a] Haggett (1977) *Locational analysis in human geography* (London) Arnold

[b] Pianka (1994) *Evolutionary ecology* (New York) Harper Collins College Publisher

c Jong(2007) *Urban ecology, scale and structure* **IN** Jong, T.M.d.; Dekker, J.N.M.; Posthoorn, R. *Landscape ecology in the Dutch context: nature, town and infrastructure* (Zeist) KNNV-uitgeverij p380 *http://team.bk.tudelft.nl/Publications/2006/Landschapsecologie/Onderdelen2/Urban%20ecolog1.doc*

scale paradox thus offers an explanation for the opposing recommendations of the different approaches, as frequently encountered in design-related problems. Accurate consideration of the level of scale may transform such scientific conflicts into complementary insights. Each level of scale thus gains its own disciplines. You should not ask a specialist in scale R=1km to provide advice regarding an object of scale R=10km. Scale articulation rationally limits the kind of categories and variables you must take into account. For design-related questions, this limitation of research variables is preferable to an implicit and arbitrary ceteris paribus supposition.

Structures breaking usual relations

The subsequent study of *relations* between variables is a common scientific practice. The values of different variables may influence each other. If these values are expressed in the form of legend units in a drawing, however, these probable connections can be broken by separating structures. For example, if the level of the sea becomes higher than the land, flood is probable. If we build a dike, however, it would be possible to avoid such flood. Conversely, if we have shops at some distance from a residential area, we can build a road or organise public transport to connect them. A structure of separations and connections thus increases the possibilities for use and allows choices that would not be probable without these design interventions. Connections and separations usually receive their own legend units in the drawing in the form of *lines*. They obey laws that are different from those of categorised *surfaces* with their probable mutual effects.

Opposite conclusions possible in different directions

One of these conjectures, published by the ecologist Van Leeuwen,[a] refers to the phenomenon that a separation appears perpendicular to a connection (direction paradox). A road causes a barrier perpendicular to the direction primarily intended to connect. These ‘side effects’ are often neglected in the straightforward causal reasoning of empirical specialists (e.g. traffic specialists calculating the expected traffic load). The development of increasingly complex systems of connections and separations may be called structural diversification. Connections and separations select contents, stabilise patterns and regulate processes maintaining less probable local states of low entropy. Structural diversification is the spatial counterpart of cybernetics and very recognisable in living systems. Your skin breathes, selecting what comes in and goes out, as do all other cells in your body. The content inside the cell is structured by numerous membranes that select the contents, stabilise the composition and regulate the processes on both sides. If these membranes are broken by chemical substances or a bullet, you will die.

Selectors and regulators

Structure is thus simply the set of separations and connections. It comprises construction, infrastructure and any other elementary combination of separations and connections in different directions. Van Leeuwen called them ‘selectors’. *Fig. 8*, shows them separating in 1, 2, 3, 4 and 5 directions while simultaneously connecting in 5, 4, 3, 2 and 1 directions. In *Fig. 9*, these directions and types of selectors are depicted with time as a dimension (regulators). Separation and connection have some relation to difference and equality respectively. To the best of my knowledge, however, no existing scientific instrumentarium is sufficient to cope with this area of study, which is so familiar to designers. However, designers still do not call it structure. This impedes communication. Designers use the term ‘structure’ to mean ‘pattern’, which is a recognisable regularity in a form. It is the only discipline to use ‘structure’ in this exclusively morphological sense.

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[a] Leeuwen(1973) *Ekologie* (Delft) TH-Delft, Afd. Bouwkunde 3412b, Vakgroep Landschapskunde en Ekologie Hb 20 A http://team.bk.tudelft.nl/Publications/2005/Leeuwen/Leeuwen(1973)Ekologie(Delft)THD%203412b.pdf

Fig. 8 Elementary selectors in space

Fig. 9 Conditional selectors

Diversification beyond variables

In the beginning, you may have thought that environmental diversification could be fully covered by naming the relevant variables, distinguishing their values and searching for relations between them. This process, however, serves only to differentiate the content and some probable relations of an environment. The content is a reduced set of implicit or explicit legend units that you may use in a design, often breaking the usual relations. The content still does not cover the diversity that can be created by design. It neglects the diversity of possible distributions of the legend units in the drawing, their concentration or sprawl, or their form. Even if you had thought that environmental diversification was fully covered by including such morphological diversification, I may have disappointed you by introducing another kind of diversification – a 'structural' one, to stabilise, select, regulate and condition the content and its pattern. Even this is not the end of the story. Suppose that there are two environments with exactly the same content, the same distribution of elements in space (form) and the same structure separating and connecting them. Even if all of these aspects are the same, people can *use* them in different ways.
Differences in use thus cause a *functional* difference between the two environments.

Internal and outward function

I must discuss the term 'function' at some length, as it has many and crucial meanings in various disciplines of science, the humanities, design and technology. One excellent translation of 'function' is 'working'. This translation immediately indicates two meanings: the way in which it works (operation) and the type of work that it does (performance).[a] Operation is thus an internal working, and performance is an external working. Given that 'operation' can be described as a combination of selectively separating and connecting in different directions, it will suffice to interpret operation as the temporal counterpart (internal functioning) of structure. It is more difficult, however, to describe an external 'performance' in these terms. Performance refers to any possible use by humans. The performance part is gradually separated from the operation part in the following remarks on function.

Function and functioning

Both 'function' and 'working' exist as both nouns and verbs (or their conjugations). As a noun 'function' describes a partial working within an assumed larger structure. For example, organs have a function (*a* performance) within an organism. As a verb, 'to function' describes a part of the workings within an assumed procedure. For example, chemical conversions 'function' (perform) within a food chain. 'Function' thus possesses 'space-time duality'.

Structure and structuring

The verbal form of 'structure' (to structure, structuring) does not indicate its own action (to operate, operating), as is the case with 'functioning' (performing). Structuring indicates an external action through which structure is *given* to some object. For designers, however, this verb refers to assigning some order or regularity – a recognisable pattern – to a form. Designers do not refer to the process of assigning a structure to the form, as intended in 'the structure of a builing'. I am glad that there is a verb ('to structure') for stabilising an object at any level of scale by connecting and separating its parts. Could we not say 'ordering', and reserve 'structuring' to mean the process of assigning operational separations and

[a] Tzonis(1992) *Huts Ships and Bottleracks Design by Analogy for Architects* IN: N. Cross, K. Dorst and N. Roozenburg *Research in design thinking* (Delft) Faculty of Industrial Design, Delft University of Technology the Netherlands, Proceedings of a workshop meeting

connections? In neither case, however, does ‘structuring’ have the same relation to ‘structure’ as ‘functioning’ has to ‘function’. ‘Functioning’ may be subdivided into the outward *performance* (by the function) and its inward counterpart, the *use* (by the user). Both are external to the function. This raises the question of whether a comparable verb exists for the external action of giving or *changing* a function. To ‘use’ a function is an external inward action, but it does not involve a fundamental change to the function, as do structuring or restructuring, which either *give* or *change* structure.

Changes of function

Changes in function often appear as a division or a combination of functions, thereby resulting in more mono-functional or multi-functional devices. The combination of functions may save space at the expense of the time required to use them, while the division of functions saves time at the expense of the space required to divide them. For example, dividing a road into lanes for public transport, private cars, cyclists and pedestrians saves time or even lives (and consequently lifetime), but it requires more space. I am not aware of a verb that covers both as the result of an external inward action. Their distinction is important, however, if you wish to understand functional diversification as intended in Chapter 6. Designers often combine or separate functions in an unconventional manner. Nonetheless, functional diversification does not necessarily suppose any external action (e.g. by a designer). It may be an autonomous, ‘emerging’ process (e.g. as known from embryology).

A function may have many sources and destinations

Aside from its possible change or its meaning as a noun or a verb, ‘function’ supposes a destination for the working of the function: a structure or a procedure in which the function takes place. In many cases, the verb tacitly supposes this structure, indicating only one of its elements as the destination. This destination is the object y, which is affected by one ore more subjects x. In most cases, x is interpreted as the *cause* of the effects on y. Even apart from y, however, the subject may have side effects on other objects in the environment. The environment must therefore be made explicit as a structure, with many connections and separations. This is even more urgent if the function of x is not only causal, but also conditional.

A function is context-sensitive

Side effects are often overlooked, and they can be different in different contexts. If this is the case, they will fade when the average effect is very convincing. The sum of the side effects of the same function in different contexts, however, may be more serious than its main favourable effect. For example, if a medicine has different side effects for different people, some of them may be so rare that they cannot be proven by statistical means. On the other hand, that ‘some’ may be many. Nobody knows, as these effects cannot be proven if each time a specific effect occurs for one very specific person within a very specific context. Function is thus a context-sensitive concept.

A function is direction-sensitive

Moreover, spatial subjects have different effects in different directions. A road connects in one direction, but it also separates perpendicular to that direction. A cause may have different effects in different directions. This demonstrates the limitation of verbal expressions. An inference or verbal expression has only one direction, whereas a drawing has many. ‘Function’ is thus also ‘direction-sensitive’.

‘Function’ has a part-whole duality

One special case of direction-sensitivity is the ‘part-whole duality’ of any function. The function of some subject s for its context c=f(s) is something different from the function of a context c for that subject s=f(c). The subject has become the object. The director ‘of’ a company is a function ‘of’ somebody ‘for’ that company. From the company’s perspective, however, the company has a function ‘for’ somebody. ‘Function’ may therefore indicate a

relation of the parts to the whole or the other way around. A function is one-sided, as it is very explicit in mathematical expressions. The formula y=f(x) refers to the function of x *on* y. Function therefore has a dual meaning:

- as whole=f(part), the working of an active partial subject (source) in the whole of a larger structure (destination)
- or the reverse part=f(whole), the working of an active whole of a larger structure (source) on a partial object (destination).

'Function' thus also has a 'part-whole duality'. The distinction between source x and destination y then should be clear. Where a destination y exists, there should also be a source x, even if the source is not determined or even nameable. This is the case when you search for the source (cause or condition) x of an observed effect y, or when you design an effective artefact x for a function y. Even if the function y is known, the artefact x may not yet exist, if it has yet to be designed.

Top-down conclusions may be opposite to bottom-up conclusions

A subject can thus have a function for a larger environment (e.g. anatomy) or, more specifically, an object within that environment (in which case you must neglect the side effects on other objects). In contrast, an environment can also have a 'function' for its smaller elements (e.g. ecology). In sociology, this inward approach was accepted as 'structural functionalism' in the 1960s.[a] The behaviour of individuals should be understood in terms of the requirements of society. Structural functionalism evoked a reaction from the 'symbolic interactionists',[b] who sought to clarify society from the perspective of individual needs, which produce an urge to exchange and cooperate. In sociology, the approach from smaller parts into a larger whole acquired the name 'anascopic' (outward). The approach from large into small acquired the name 'katascopic' (inward).[c] The application of this forgotten distinction extends beyond sociology. Failure to distinguish between the outward and the inward approach can generate confusion. The conclusions of the two may appear to contradict each other. For example, a ball can be described outward as concave and inward as convex. A chairman searching for a compromise between convinced anascopists and katascopists could propose that the ball has an undulating form. Many compromises in science and the humanities show this kind of bias. The function of a tool for its user is largely outward, while the function of a house for its inhabitants is inward. A house is thus not a tool, as some may claim. Architecture is something other than industrial design.

The double-edged function of a boundary

Yet another duality exists as well: the problem of a boundary as an acting subject. What is the function of a boundary? The lines drawn by a designer consist largely of boundaries. If the functioning subject is a closed boundary, this double-edged separation influences at least two different objects: the interior *and* the exterior. In this case, 'function' may refer to both inward and outward influence. For example, the walls of a house may keep the inhabitants warm and safe inside, while having an impact on the flow of the wind and the visibility of the landscape on the outside. The function of the wall has no unequivocal source or destination; it influences other functions – each with its own source and destination – in different ways. It obstructs external functions (wind, accessibility) and it makes different internal functions possible. The boundary is not 'active' in and of itself; it *prevents* and *allows* actions. It *conditions* other functions (as always happens in spatial design). The 'function' of separations and connections may thus also have a 'boundary duality', which blurs the clear distinction of source and destination.

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[a] Parsons (1966) *Societies: Evolutionary and comparative perspectives* (Englewood Cliffs, N.J.) Prentice-Hall
[b] Zijderveld (1973) *De theorie van het symbolisch interactionisme* (Meppel) Boom
[c] Berting (1976) *Ruiltheorie* (Intermediair)0528

A function is scale-sensitive

The meanings of 'function' differ substantially at different levels of scale and time spans. For example, CO_2 has a different function for a plant in its lifetime than it does for the Earth during its existence. Given the many tacitly assumed levels of scale in science and humanities, scale confusion leads to language confusion. It is therefore unacceptable to speak about a function without mentioning the assumed spatial or temporal level of scale of its intended working. This level of scale determines the variables that must be taken into account. Although this form of scale sensitivity may seem similar to the parts-whole duality, it is something else. As stated before, the part-whole duality can play a role at any scale.

Limits of unidirectional language

'Function' is used in many contexts, thereby acquiring a variety of context-sensitive meanings, each of wich assumes a different source and destination. Empirical research primarily distinguishes and names a single destination as the effect y. The observed effect is a crucial part of any problem statement: 'Why y? How y? What causes y?' The effect should thus be clearly bounded. From this perspective, you can efficiently search in different directions for a cause, the unknown or suspected 'x' and its working on y. In some cases (e.g. exploratory research), x may be unknown, while in others, it is made explicit in a hypothesis to be verified of falsified. In some situations, a combination of different causes x may be accepted if no other option available. A combination of effects y is more difficult to accept, as it blurs the problem statement.

That limitation of y and x may also be forced by the verbal language required to express and report the results. In linguistics and logic, a 'complete sentence' indicates the intermediate position of a verb (an operation or a performance) between a subject and its object. In a complete sentence formula y(x) – to be read as 'y as a working of x' – the verb is expressed indeterminately by the brackets ( ), thus enclosing 'x' as an active subject. A mathematical function f(x) may quantify the working between 'variables', usually distinguished as a single dependent variable y=f(x) and one or more independent variables x. In physics, 'function' relates cause x and effect y (or its probabilistic equivalents). In biology, it relates organ and organism, while in sociology, it relates individual and group. In design and technology, function relates artefact and environment (including the user).

Chicken-and-egg duality

The field of biology, however, has struggled with a chicken-and-egg problem between cause and effect. The effect can become a cause in a repeating sequence, thus blurring the usual cause-effect (c-e) sequence. The problem emerges in the many feedback systems observed in biology or technology. The imagined effect subsequently influences the cause through feedback. Whenever humans are involved, a given situation can even raise a plan of successive actions (procedure), in which the imagined result *precedes* the realised actions as a 'goal'. The imagined 'goal' (an intended result of action) subsequently becomes the *cause* of the actual action. This raises the question of what is the cause and what is the effect: y(x) or x(y)? To avoid confusion, the process c-ec-e must be subdivided into proper c-e cause-effect components in order to avoid an e-c sequence. In this process, 'function' may acquire a 'chicken-and-egg duality'.

Eufunctions and dysfunctions

Finally, a normative distinction exists between eufunction and dysfunction. This distinction is also rooted in sociology. From the perspective of the survival of a society, a criminal is usually assumed dysfunctional, while a citizen practising the society's values is assumed eufunctional. In biology, eating is eufunctional, while being eaten is dysfuctional. Even 'using' implies withdrawing means from other potential uses at the same time. For example, to provide families with safe, warm housing may have undesirable effects at a larger scale, due to the exhaustion of energy resources. At a smaller scale, such provision could make the inhabitants more vulnerable by allowing them to become accustomed to a safe and warm environment, thus catching a cold as soon as they open a window or leave their

homes. In many cases, the word ‘function’ is implicitly used as ‘eufunction’. We sometimes use the phrase ‘not functional’ when we mean ‘not eufunctional’. The word ‘malfunction’ supposes a disappointing eufunction (the ‘proper’ function), but not yet a ‘dysfunction’. In this way, many (if not all) eufunctions may have dysfunctional side effects or costs. ‘Functional’ has two normative faces that must be balanced as a value for survival by decision-making. In its foundation, ‘normative’ refers to any assumption about the impact of human action on the life expectancy of living sets. ‘Life expectancy’ assumes a time left to live, along with its ‘value’. The ‘living set’ may consist of individuals (liberal values), families (confessional values), communities (social values) or even include other life forms. This is the subject of the following paragraph.

Different evaluations of function

The distinction between eufunction and dysfunction bears all of the ambiguities associated with the term ‘function’, as mentioned above. Any evaluative assessment demands explicit mention of these ambiguities. You can assess the function as an object expressed in the form of a noun (do we need it?) or in the form of a process (does it work?). You can assess how it works (operation) and what it does (performance). You can criticise the side effects, thus stressing its context sensitivity. You can compare the impact of the function in different directions, and you can balance its profits and losses in all of these directions or in only two, in order to assess the function of a boundary. You can consider the profits for the whole or for the sum of its parts. You can repeat all of these assessments at any level of scale. Finally, you can assess the profit for a chicken or for an egg.

The relevance for science and the humanities

The second ambition of this study is to be understandable, relevant and useful for science and the humanities. This ambition must apparently remain under the shadow of the relevance of science and the humanities for design and technology, and it therefore has a strong chicken-and-egg character. Many design questions involving function, structure, form and content remain inaccessible to science and the humanities. Questions about functions seem to be most accessible. They are answered by programming and evaluating research. There is nevertheless considerable language confusion regarding the many meanings of ‘function’. Designers assume many functions in their designs that do not perform as expected after realisation. Other functions or ‘effects’ still cannot be expressed in researchable terms. At the level of a building (construction), ‘structure’ is scientifically well developed as chemistry, mechanics and building physics. At larger levels of scale, however, much work remains. ‘Form’ is underdeveloped. ‘Content’ continues to lack many scientifically explicit variables that are relevant in designs, and which are only partially explicit in their legends. The primary difficulty involves the expression of such open and ill-defined questions in a language that is accessible to empirical researchers. Conversely, researchers may become aware of the problems faced by designers in the process of making a drawing. In this regard, this study may help researchers to recognise some of the limitations to their own distinctions, language and methods. If they manage to extend these boundaries, a rewarding field remains to be explored.

1.4 Politics and decision-making

To cooperate or not to cooperate

At any level of scale, political and decision-making processes assess the desirability of functions; in some cases, they may change functions as well. Such assessments may be different in different spatial, ecological, technical, economic, cultural and managerial contexts. They are context sensitive and thus difficult to generalise. All political processes must nevertheless answer the same question: 'What should we do together, and what is your own responsibility?'

In a democracy, the left wing of a political forum emphasises the left part of that question, while the right wing focuses on the right part. War, floods or starvation can force cooperation. Disasters increase the urge to do things together. Situations that you cannot handle on your own will shift your political inclination to the left. If disasters fail to occur, however, your prosperity and your own opportunities may increase. This makes you less dependent and less willing to pay taxes for public services you no longer need. Your political conviction will thus shift to the right.

Economical cooperation in public services

Even in the latter case, however, you must admit that some functions perform more economically at a scale greater than that of the individual household. You cannot always maintain your own army and police; you cannot build your own dikes around your house and grow your own crops at the same time. For this reason, you accept the necessity of dividing these tasks, selling your own specialisation while buying the others that you need. However, everybody's business is nobody's business. Who is going to build the roads that are needed in order to exchange goods and services? Who is going to build the dikes in order to avoid flood? Who is going to safeguard your property and rights? Who is going to provide the functions that are used by everybody when it is impossible to calculate your fee according to your share in and profit from common facilities? Moreover, if you do not agree with the owners of these facilities with regard to your fee, who is going to judge and punish? You decide to delegate this responsibility to a territorial public authority accepted by everybody. If this authority is not accepted by everybody, the threat of chaos and violence may drive you to accept a dictator who promises to restore law and order, or you may migrate to another country.

Technical breakthroughs change the context of politics

Although the situation described above may be a caricature of the political process, it does demonstrate the role of scale within the context of politics and decision-making. Given this role, it is reasonable to ask what each household should do on its own and what would offer the best economic benefits from sharing at the local, regional, national or even international level? The development of technology changed the economically optimal scale of many functions. The invention of printing (1439) decentralised knowledge and religious authority. The invention of the steam engine (1777) centralised the dispersed system of home production into industries concentrated in cities. The invention of the mobile petrol engine (1886) de-concentrated households into suburbs, while further concentrating specialised production. The invention of the transistor (1947) made computers and photovoltaic cells possible, thus re-arranging the optimal scale of many functions in both directions. Politics and decision-making must react to these technical (and thus economic, cultural and managerial) shifts of context. National competences must be transferred upwards to international governments or downwards to regional and local authorities. Although movements in both directions exist at any level of governance and decision-making, one ecological factor drives the necessary scale of many functions upwards. This factor is the growth of the human population.

Population increase raises new urgencies

The doubling of the global human population in the past forty years has decreased your

space on Earth by half, from 10ha to 5ha. In one of his impressive letters to me, Evert Croonen wrote, 'You are not born to hear that you are redundant'. For millions of years, the Earth was inhabited by some three million people. With 100km^2 for each inhabitant, they had ample to explore. They lived in small wandering communities of some 30 hunters and gatherers, exploiting an average of 10 000km^2. They met each other every day from birth to death. Individuals were forced to adapt their behaviour and accept that of others, because without the others, the individual inhabitants would be lost. It is only very recently (10 000 years ago) that the world population started to increase, due to the neolithic invention of agriculture. This accounts for less than 1% of the period in which we learned to be human. It is not very likely that our genes have undergone substantial adaptation to the new context in such a short period of evolution.

Changing conditions for humans

In contemporary times, you no longer count on a small and stable community. Apart from your home and family, there is no stable context to reflect who you are. You are part of an anonymous multitude from which you are free to choose your own partners, although they belong to other networks. They can easily let you down, as there are many alternatives. You are an interchangeable alternative. You must compete with others in order to become a preferred partner. Within the context of this competition, you become inclined to identify other communities, nationalities or races as inferior. When you were five years old, you wanted to become famous; at 10, you wanted to become rich and at 15, you wanted to be attractive. Ultimately, you have always wanted to be someone else, in order to win the interest of others. You must offer something special that others cannot offer. It should not be too special, however, as otherwise you would not fit into the communities of the others you are trying to impress. This situation reflects a kind of tolerance similar to that depicted in *Fig. 6* and *Fig. 7*. On the other hand, you may belong to many communities, and you may thus have many identities to maintain. You have many specialisations that you can advance in order to make yourself interesting to others.[a] The often forgotten Dutch philosopher Carry van Bruggen eloquently clarified the crucial role of *distinction* in human life.[b] For many decades, this distinction was popular in Dutch political circuits..

Identity

In addition to economic questions, the contemporary political system must address an even more fundamental question: the pressing question of identity. Given its tertiary priority in this study and its economic interpretation, the political objective of this inquiry is elaborated briefly in one of the final sections (Chapter 6 on page 215, Chapter 7 on page 245). Public identity has currently been reduced to the information that a police officer might ask in order to determine your 'identity': 'name and address, please'. It is reduced to your origin in time (descent) and space (the place where you live). If descent has ceased to be important, the place where you live has become a crucial part of your identity. If it looks the same as those of everyone else, it fails to distinguish you from others. Within the context of this study, it should motivate territorially based political decision-makers to make living environments more diverse. It has to do with territory, the part of the Earth's surface that you defend as your unique property. Property has become more important since the neolithic revolution. It forced communities to remain close to their growing crops, due to threats posed by others. Human communities became sedentary. While the money-based economy and the industrial revolution made parts of your property mobile, they decreased the mobility of your dwelling place. Even if you move every seven years, you should have your own unique safe place, which is capable of protecting you and your other possessions until you return from any your travels.

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[a] Jensen; Wijnberg (2010) *Dus ik ben, een zoektocht naar identiteit* (Amsterdam) Bezige Bij. This booklet summarises the specializations through which you gain an identity: your thoughts (Descartes), your feelings, your work, your name, your community, your suffering, your past, your love, your acknowledgement, your consumption and your body.

[b] Bruggen(1919) *Prometheus* (Amsterdam 1986) Oorschot http://www.dbnl.org/tekst/brug004prom01_01/

The possibilities of diversity

Individual or environmental identity means *difference* from the rest and *continuity* in itself. If you are the same as everyone else, or if you change in such a way as to become unrecognised, it will be difficult to identify who you are. If your house is similar to those of many neighbours, or if your living environment changes dramatically, it will become difficult for you to recognise your place. In some disciplines, however, identity appears to indicate the opposite. For example, in mathematics, 'identity' is symbolised by the '=' sign. Identity thus appears to indicate an *equality*, even if the terms on both sides of the '=' sign *change*. It fails to address the question of why they are written down *differently* if they are equal. An equation has little use if the terms on both sides of the '=' sign are the same. If you look at the Latin background of the word 'identity', it appears to be a contraction of idem-tidem (*repeatedly* the same). It is sameness in time: continuity. For my purposes, this paradox is resolved in the regulation theory of Van Leeuwen.[a] This theory accepts that equality is a special *kind* of difference. Equality is thus a non-existent 'zero-point' of difference. In time, and continuity is a zero-point of change. Everything differs or changes more or less, even if it seems to be (or to remain) the same in many respects. This position seems to be at odds with sciences that attempt to *generalise*, and this touches upon the core of any inquiry into environmental *diversification*. Aside from this, Van Leeuwen made yet another discovery.

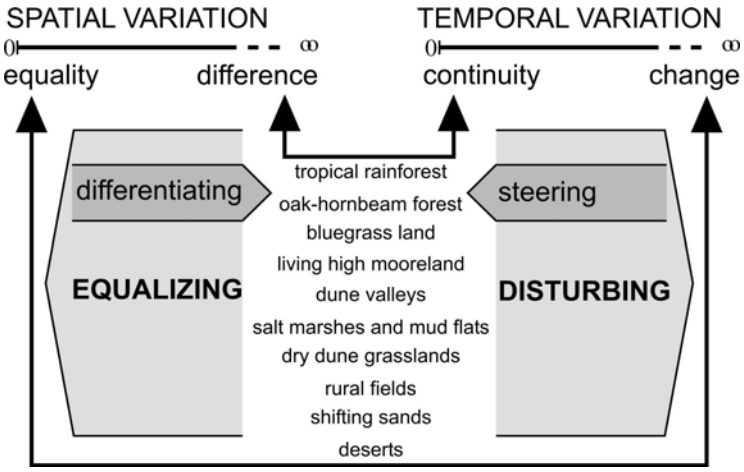

Fig. 10 Van Leeuwen's regulation theory

Within the field of ecology, diversity is often related to stability, near the zero-point of change. At some levels of scale, diversity and stability (tropical rainforest) appear to be related to equality and change (desert, see *Fig. 10*). Within this context, the mathematical '=' sign thus does not mean 'equals'; it means 'becomes' (:=). This reflects a change – a special kind of difference in time. This nonetheless fails to identify the cases in which you must still use the '=' sign. Even though the expressions on both sides may be different, they express different views of a reality that is assumed to be the same. It thus expresses different verbal representations of the same reality. Yet another difference remains: the frequently neglected difference between language and reality.

Arguments for diversity

Relevance for decision-making does not suppose to provide a proof of the *desirability* of environmental diversification. Although this thesis does not make this choice, it does support arguments for more solid and explicit motivation, based on the possibililties of diversification by design. The counterargument is obvious: 'Standardisation is efficient.' This, however, raises the question for whome it is efficient and at which level of scale in space and time. In the long term, Nature apparently chose for biodiversity at many levels of scale. After billions of years, this appears to have offered the best insurance for life against disasters and environmental change. Diversity is a prerequisite for the possibility of choice for future generations. These may be plausible arguments, but they do not yet represent a choice.

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[a] Leeuwen(1966) "A relation theoretical approach to pattern and process in vegetation" Wentia **15**: 25-46
Leeuwen(1973) *Ekologie* (Delft) TH-Delft, Afd. Bouwkunde 3412b, Vakgroep Landschapskunde en Ekologie Hb 20 A
http://team.bk.tudelft.nl/Publications/2005/Leeuwen/Leeuwen(1973)Ekologie(Delft)THD%203412b.pdf

Assumptions of identity

In addition to scientific arguments (e.g. sustainability, perception), philosophical and political arguments can plead for environmental diversification. An analysis of philosophical arguments leads to the concept of identity as difference from the rest and continuity in itself. Any political conviction is ultimately based on a portrayal of humankind, and any portrayal of humankind supposes a concept of human politics. Likewise, any political conviction implicitly supposes an answer to the question, 'Who am I and who are the others?' The answer to this question leads to the practical question mentioned previously: 'What should we do together, and what is your own responsibility?' However elusive the first question may seem, the possible answers to the second can be categorised systematically according to the level of scale. What should I do together with my neighbours or with the other inhabitants of this municipality, my country or my world? This question is relevant for policymaking in any political constellation. From these answers, the desirable kinds and quantities of environmental diversification can be derived. These answers even include environmental homogeneity as a special kind of diversification. The political objective and relevance of this study comprises such an analysis. It requires the creation of a terminology that enables a debate based on what is possible, rather than what we implicitly expect from other people.

'Diversity' is scale sensitive

In an attempt to develop a terminology that may be useful in design, science and policy, I set out to expose the typical ambiguities of diversity as a concept. In addition to being fatal when they emerge between science and technology, these ambiguities can enhance the appearance of consensus through the political manipulation of scale or other aspects (see *Fig. 7*). If an alderman promises only small dwellings to the inhabitants of an urban-renewal area, in an effort achieve a balanced size-diversification of houses, the residents could interpret this at the level of their neighbourhood. It is possible, however, that the alderman was referring to the scale of the town, thus realising larger dwellings elsewhere. Diversity is thus a scale-sensitive concept. At an urban scale, diversity may imply homogeneity at a neighbourhood level.

Relevance for politics and decision-making

Except for the political exploitation of ambiguities in order to camouflage conflicts, the existing terminology produces twisted reasonings if differences in the level of scale addressed in arguments and conclusions are not made explicit. If you claim that living, working, traffic and leisure hinder each other and should therefore be separated and concentrated in different parts of a town, the distance at which the nuisance actually has an effect may not be the same as the level of scale referred to in the conclusion. Unambiguous terminology is a prerequisite for any fair debate. In addition to its importance for science and technology, the clarification of terminology is of great political relevance. Most importantly, however, such clarification serves to facilitate the debate between these realms.

1.5 The art of questioning

Questions of possibility in terms of probability

Despite the little effort required to bring design and policy into line with each other, it is only with great effort that a technical attitude can be combined with an empirical or theoretical perspective. Antagonism exists between craftsmanship and research, as experienced by any designer in the process of collecting data for design. The more data you collect, the fewer liberties remain for the design. Conversely, the more creative designers may be, the less interest they are likely to demonstrate in facts. Such antagonism reflects the contrast between a projective and a retrospective attitude, between an expressive and an impressive character or between a holistic, spontaneous, conditional approach and an analytic, causal approach. Such antagonism may be responsible for the generally accepted division of tasks between the two sides. They are related to each other in the same way that inhaling is related to exhaling. Although both are necessary, they are always at odds with each other.

Synthesis and analysis

One possible consequence of this dichotomy is a breakdown in communication or even a controversy between designers and researchers. Designers may be of the conviction that the increasing specialisations of empirical research impose an intolerable restriction to the integral field of vision required for design. Spatial designers must cope with the totality of a physical, biological and human reality, in addition to a constantly shifting context of space, time, ecology, technology, economy, culture and management. On the other hand, researchers may be convinced that the restrictions of scientific disciplines offer the only way to avoid the danger of unfounded, muddleheaded or 'all-encompassing' speculations. Without a doubt, many difficulties could be resolved if designers were able to ask only clear and unambiguous questions – but this is seldom the case. In a design process, it is hardly ever the case that a single problem must be resolved at any given time. The design process is more likely to entail a *field* of problems that involves many stakeholders and that changes both during and through the actual process of sketching. Moreover, most educational programmes in design place less emphasis on cultivating the ability to formulate problems and questions than they do on cultivating the ability to produce possible solutions, concepts and pictures – in other words, on cultivating answers.

The art of asking questions about nameless gaps

Asking questions in such a way that you receive the answer you need is an art that requires extensive education. After all, the ability to ask questions requires the ability to recognise *gaps* in either personal or more general knowledge. You cannot see the emptiness of these gaps and then identify it as an object (Meno's paradox[a]). The awareness of nameless gaps is a very difficult task in and of itself. It is thus necessary to approach gaps from the outside. The awareness of gaps cannot originate from within any single black centre. Such awareness assumes a certain measure of holism, an overview from which the emptiness can be felt (e.g. in the act of designing). It is thus even more difficult to describe or circumscribe the recognised gap clearly and in scientifically understandable terms, simply *by virtue of the fact* that it is a void. In order to ask a question, you must already have some level of awareness regarding the unknown and its boundaries. For this reason, the more you know, the more you become aware of what you do not know. It is as if you are walking over an iron grating as if it were a solid floor; while looking down, the surface appears to consist primarily of gaps.

[a] Plato (380BC) *Laches Protagoras Meno Euthydemus* (Cambridge Massachusetts 2006) Harvard University Press Loeb Classical Library series page 299

Founding design decisions on soft grounds

Designers often feel an urge to found their design decisions, but they usually cannot formulate the voids of their knowledge in a scientific manner. In many cases, this drives designers towards a dilettantish and speculative type of theory that attracts little more than ridicule within a scientific context. Nonetheless, such reactions from the empirical-scientific side are no more justified than are the designer's feelings of being fooled by partial, general or obvious truths that do not fit within the governmental, managerial, cultural, economic, technical, ecological or spatial context at hand.

Studying vague questions an ill-formed problems

Empirical scientists would do better to consider the constructions that designers develop in order to justify their design decisions in a scientific manner, in the attempt to answer questions that they obviously cannot formulate and for which science evidently still has no answer or even terminology. To understand this situation, you must step down to the most fundamental designing act of any designer (not only of architects or urbanists, but of mechanical engineers and other types of designers as well): separating and connecting. On paper or on a computer screen, this design act is expressed through lines that somehow represent a realisable separation or connection (together called selectors if they occur paradoxically at the same time but in different directions; see *Fig. 8*). The form and function of these selectors within a spatial context are so complex that they cause designers to fall back on mystifications in order to justify their designs.

Convincing by form

For example, suppose that an architect draws a line representing a separation between the 'inside' and the 'outside'. Perhaps you have experienced the semi-poetic, tangled, associative and scientifically nonsensical speculation that architects usually develop with regard to the 'inside' and the 'outside' in order to justify the course of the lines that have been drawn. Within the context of such speculation, the 'outside' becomes preferably enclosed by the 'inside' in such a way as to bring the public area (and thus the whole of human society and the universe) inside the seclusion of the personal, the familiar and the domestic. At the same time, this intimacy exposes itself in the non-personal – the 'outside' – such that the humans involved feel guided through the field of tension between the private and the public by the forward pressure towards the 'inside' – the safe, dry, warm singular individuality, and the process continues. The discourse is often clarified by vertical, horizontal and circular movements of the arms and hands intended to transform the audience into speechless insiders (and thus silent accomplices) within an ultimate truth.

What, how, why questions

In my opinion, therefore, merely brushing aside such an architect's story as nonsensical does not demonstrate a scientific attitude. Such an attitude should involve questioning the questions that the designer is attempting to answer. The answers given by the architect that should be of less interest to you than the unspoken questions from which they originate. These questions are apparently so burning that they justify such a story.
Proceeding from the assumption that connecting and separating is the essence of any design, these questions can be analysed in three categories:

- *What* exactly is it that I am separating (e.g. cold from warm, dry from wet, safe from unsafe, public space from private space), or what am I connecting? In more formal terms, which environmental variables are varying here, in which direction and by which values?
- *How* can I separate the different environments (e.g. straight, curved, in several stages or kinds for each variable; sharp or vague, discrete or continuous, complete or incomplete, by material or by distance)?
- *Why* should I separate these values of imaginary variables and not between those of other variables? Why should I separate them in this way and not in another way? Why should I want to separate these two environments at all?

Contradictory answers from different directions

Science obviously has answers for many of these questions. If you ask a specialist in physics, the answer may be that you are separating between dry and wet or between warm and cold and that you can separate them most economically by a sphere. These answers nonetheless leave the 'why' question open. A biologist may be able to address variables of safety and use for the survival of an organism, while a specialist in the humanities would be likely to refer the designer to a psychologist for the private area, to a sociologist for the public area, to a geographer and an economist for their particular subjects, and so on. Each of these specialists would provide different or even contradictory answers. Specialists provide few arguments to balance them in a line between the 'inside' and the 'outside'. Given that many lines must be drawn in a design, it is perhaps more attractive simply to draw them, simply to make a design devoting all that much attention to the paralysing question of, 'Why this way?' Once the lines have been drawn and the design is ready, science and the humanities can address the consequences and conduct impact analyses. This is too late for the designer, however, who can learn only from the disapproval of various disciplines with regard to earlier designs. For this reason, experienced designers often cease to see the problem and thus teach their students as if there is no problem.

A grid of hypotheses

This study aims to be relevant for designers while being understandable to empirical researchers as well. It attempts to formulate the questions that a designer should ask. It attempts to cover the area of desired knowledge with a grid of hypotheses upon which you can walk, even though looking down provides a view of an overwhelming number of gaps. The grid actually consists primarily of gaps, filled in sporadically by existing empirical matter. Where the gaps are larger, you must be cautious. These gaps reflect areas for which science and the humanities do not provide any definitive answer. This grid (or network) of hypotheses is intended to provide a grasp of the totality of problems with which spatial planning and design must cope from the perspective of environmental diversification. It is also intended to raise awareness of the gaps and to make them explicit. Many gaps may have become localised by the terminology offered here and formulated as questions that have remained unanswered for so long that we have forgotten to ask them.

Answers to the preceding questions

This study attempts to analyse some of the answers that designers offer, along with their implicit choices and tacit assumptions. These answers should be unfolded in such a way that they can be transferred from handicraft into explicit and questionable assumptions. Some may be transferred into empirically verified propositions. The implicit choices and assumptions of design, however, constitute only a small part of a much larger range of assumptions about possibitity. This may subsequently result in a much greater area to be explored. Moreover, the possibilities that extend beyond the most probable futures we face are more necessary now than they have ever been before. The ecological crisis is raising questions that force us to find new solutions. The boring habit of reproduction, copying and combining should be replaced by true mutations, thus demonstrating true creativity.

Uncovering implicit suppositions

In many cases, however, the transition from implicit to explicit assumptions is a painful process. The usual imaginations, which are broadly shared with many other people, may unfold into contradictory assumptions. You may be forced to leave the familiar and safe imaginations that have thus far proved so profitable, because you shared them with your clients. Nevertheless, history contains an abundance of examples with which to prove that the wisdom of the crowd is not always that wise. In this study, I am painfully aware that I am part of this set of shared tacit assumptions known as 'culture'. You cannot explain to a fish what water is until it is drawn out of the water. Although this text may contain many hidden assumptions, I can at least try to make some progress.

The sequence of questions

The overall structure of the study is determined by the questions addressed the previous paragraph: ‘What’, ‘How’, ‘Why’. The parts of the study answers these questions approximately as follows:

What varies in our environment?

- A catalogue of environmental variables (Chapter 3)
- Morphological diversification (Chapter 4)

How could our environment diversify?

- Morphological diversification (Chapter 4)
- Structural diversification (Chapter 5)
- Functional diversification (Chapter 6)

Why should our environment diversify?

- Functional diversification (Chapter 6)
- Desirability of diversification (Chapter 7)

Shouldn’t it be the other way around?

You may wonder why the desirability of environmental diversification is not addressed in the first section. Shouldn’t I first explain why our environment should differentiate at all before I begin to address questions concerning what must be differentated and how this can be achieved? At this point, we directly touch upon the priority of this thesis. The objectives are primarily technical and oriented towards design, accompanied by a scientific, empirical-theoretical objective and the objective to be useful for politics and decision-making. Designers, who are preoccupied with means and possibilities, first seek to show what the possibilities are before offering choices to their clients. Social scientists, who are preoccupied with values, aims and expectations, seek to formulate the desirabilities and problems first, before listing the possibilities for a solution.

Choice assumes alternatives

From the perspective of design and technology, I follow the argumentation that you must first be aware of the alternatives and their consequences before you can choose. You must first know what environmental diversification can be, before you can choose for any of its manifestations. A simple definition cannot raise an image of all forms in which environmental diversification can appear. That requires a number of chapters. The chosen sequence thus has the important didactic and logical side effect of increasing complexity and decreasing possibility to verify. The content of theoretical constructions and the premises necessary in order to make any progress are likely to increase in the course of the argument.

Variables and their values

The catalogue of environmental variables has nearly no theoretical background. The choice of variables and their values (and the way I bound them to scale alone) can be disputed without much reference beyond that which you can observe everywhere. In this section, therefore, I do not attempt to provide a closed scheme in order to avoid all gaps and overlaps. On the contrary, the reader is challenged to find more than what I could do in the allotted time.

Form, different ways to distribute them in space

The section about morphological diversification subsequently assumes the existence of environmental variables (e.g. those that have appeared in the catalogue), along with their scale-bound character. The section then adds the assumption that each form can be localised at a scale of morphological diversification between the extremes of total accumulation and total sprawl.

Structure, different ways to stabilise them

Structural diversification thus assumes these pronouncements about content and form in the elaboration of the subject, as presented here, although it does not pretend that this is the only possible way. These pronouncements represent one of the possible elaborations, thus demonstrating that elaboration is indeed possible, even though it is one of the few that ever to have been elaborated at all. This elaboration thus has specific premises, but you need not accept these particular assumptions in order to understand that the development of functional diversification in the following section requires a concept of structure.

Function, different ways to use them

Some concept of structure and structural diversification (whether tacit or not) must necessarily precede any concept of function and functional diversification. The concept of function thus also contains hidden assumptions regarding form and content, although they need not be the ones I present here.

The section about functional diversification introduces ‘humankind’ into the argument. It is restricted to the diversity of functions that different environments may have for humankind and society. It is thus necessary to assume that these environments do have structure, form and content. If you accept this assumption, this section will be necessarily more complex than the previous sections.

Intention, different ways to judge them as desirable

Desirability thus supposes that environmental diversification serves some function for humankind and for society. It is impossible to discuss the desirability of environmental diversification until you have sketched an image of all forms by which the concept of environmental diversification may acquire a meaning. This image need not be complete. In this study, it is also far from complete. The exploration of its meanings with regard to content, form, structure and function, however, establishes the outlines by which the desirability of environmental diversification *at least* should be discussed.

Producing choice

In discussing the desirability of environmental diversification, I am skating on very thin ice. The preparation of a choice includes the design of alternatives, although this implies a choice amongst alternatives existing within a multitude of possibilities. Their evaluation is only partly empirical. Multi-criteria decision analysis can help inform choices between variables, as long as there are not too many criteria and as long as their values can be weighted. If these conditions are not met (which is usually the case), this form of analysis merely prepares the choice by raising awareness of the alternatives and their values; in the end, choosing will replace knowing.

The values themselves may have technical and scientific aspects. Some values of diversity (e.g. perceptual or theoretical values) can be underpinned and verified through empirical research. Other aspects (e.g. balancing the desirable against the possible and estimating the associated costs) require technical expertise and calculations.

In principle, therefore, the utility of all of the objectives of this study is manifest in answering the question: ‘Why should our environment differentiate?’ This question is also the most complex and final question. Nevertheless, it remains unanswered. If it could be answered, then there would be no choice.

Method used for selecting the variables

The first question ('What varies in our environment?') has hardly any political or technical implications. Although its answer may appear to be an empirical exercise, I have my doubts. For this exercise, I collected hundreds of Dutch topographical maps, copied pieces of 10cmx10cm with radiuses of R=300km, 100km, 30km, 10km, 3km, 1km, 300m and 100m at the appropriate scale and pasted them into eight albums, according to radius. I then took a compass to each album, with distances of 300km, 100km, 30km and so forth between the legs. On every page, I closed my eyes and placed the compass blindly on the map. I then opened my eyes, each time asking myself, 'What is the difference of the environments around the point at which the legs came down? Is it characteristic for that level of scale? Could it be influenced by design? How should I identify these environments as values of a variable or as legend units for design? How should I identify the variable containing both values? Can I imagine a zero point of the variable?' This exercise was an attempt to avoid hidden assumptions, with the goal of being as objective and empirical as possible. Whether this goal was met is open to question. I assumed that scale matters. I assumed that the maps represented a reality that I could imagine at that level. I assumed that my imagination bore some resemblance to reality, and so on. At any rate, the exercise resulted in the awareness that the choice of variables for studying diversity cannot be anything other than accidental. It could be argued, however, that this is the case with any empirical research.

Doubts regarding the ultimate possibility of rational choice

The methods of empirical research contain many rules and restrictions, as known from methodology books. You should have a well-formulated problem, an aim, starting points, proper statistical instruments and so on, but the choice of a research hypothesis should be free.[a] My experience suggests that the choice of variables should be free as well. Many variables are chosen implicitly by custom, and they are no longer disputed within the discipline. Physics has mass, time and length, while sociology has age, gender and income. The problem (e.g. criminality) raises new variables (e.g. number of robberies), and these new variables are immediately related or reduced to the well-known variables (e.g. age, gender, income). Although this process is experienced as natural, custom is essentially accidental. Even if the variables and their values are selected according to a criterion of observability, they remain accidentally chosen by the reach of the human senses and the available instruments to expand their reach. I am even more concerned by the fact that the measurements, relations and conclusions are reported in a language that may bear hidden assumptions in the prefabricated categories of common words or legend units. In this study, I leave these concerns for future research.

The question of relevance and completeness

How can you decide whether the accidentally chosen variables are appropriate for describing and explaining environmental diversification? How can you decide whether they are sufficient in order to find the relationships that are relevant for future design?
In this thesis, I resolved these issues simply by distinguishing as many variables as I could imagine, accepting that many would overlap and that many more could be found or proposed. I decided not to bother about their possible overlaps – that would be a concern for later. Upon studying their relationships, the overlaps (and consequently double counting) or truisms would appear. This would allow anyone to reject some variables and propose others. This could be accomplished through empirical research aimed at discovering which relationships actually exist, or by design study aimed at identifying which relationships may be possible. In design study, the choice of variables is largely restricted to those that can vary in space (a relationship with length). If they cannot be related to space, I assume that they are not relevant for spatial design. This restriction was already hidden in the method used for finding the variables, as described above and as further elaborated in Chapter 3.

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[a] Groot(1961) Methodologie: grondslagen van onderzoek en denken in de gedragswetenschappen (Den Haag) Mouton & Co

After ‘what’ comes ‘how’

Design-related studies should thus result in ‘how’ questions, which are not aimed at discovering how variables and their values *are* related, but at inventing how they *can be* related. The current study formulates these questions in Chapter 4 (morphological diversification) with regard to the relationship of the variables and their values to space in terms of distribution. In Chapter 5 (structural diversification), these questions concern the relationship of the variables and their values to construction in terms of ‘selection’. Structure is thus defined as the set of separations and connections. Any combination of separation and connection is called a ‘selector’ (see *Fig. 8* and *Fig. 9*). Selectors influence and stabilise the values of environmental variables in space. They stabilise a difference that would not exist without them. For example, a window is a selector – a kind of sieve. It separates temperature, and it connects light, thus conditioning a stabilised difference. This implies that a different relationship remains between the two variables. In Chapter 5, several possible connections between the variables and their values are discussed at different levels of scale.

The ‘how’ question is the core of design

Given the priority assigned to design and technique, the ‘how’-question forms the core of this study. The answers – the investigation of structural aspects of environmental diversification, flanked by their morphological conditions and functional consequences – are of primary relevance to designers. In this argument, the designer is no longer considered exclusively as the provider of form or function (if such has ever been the case), but primarily as the provider of structure. The designer is thus the one who knows and varies openness and seclusion in all of their meanings and at different levels of scale. The designer is the one who conditions isolation and communication in all of their spatial manifestations, who constructs separations and connections, static and dynamic spaces, residential places and spaces for movement, shells and networks. Structure is thus the means by which a designer influences function and form without determining them. This can be accomplished only if the concept of structure has been elaborated with substantial and applicable content, with an equivalent position between form and function. This study aims to provide a modest contribution.

Preceding and following chapters

The five parts of the study may now be recognised in the terms of content, form, structure, function and intention, preceded by chapters containing problem statements and methodological accounts. The study is followed by a conclusion addressing several aspects of its applicability, a summary, a list of literature (with several remarks) and a list of key words with several definitions.