1. Introduction

The idea of working with spatial scales is not new, neither in architecture theory in general nor within space syntax theory - as can be seen in e.g. Hillier (1996) and Read and Budiarto (2003). What this paper attempts, is to make such a discussion and such knowledge more concrete - to begin to find out how, in configurative systems, spatial scales work together, when they appear and if there are regularities in their relationships or uses that can aid our understanding of architecture.

The research and findings presented are what began as a sidetrack, which proved to be of importance, in a research project on how spatial systems work to produce meaning in society - or, at the recently finished stage of a licentiate thesis, more precisely, how the idea of knowledge is produced through the spatial systems of public libraries (Koch, 2004).

In this project, it was first intended to simply compare different scales of space analysed through space syntax means, and see which of them would be best to work with based on found correlations. It turned out, however, to provide more, and more interesting findings than that - namely that all the scales were important for movement, and that all scales were existing simultaneously, working in and through each other to produce correlations between space and movement. The correlations were different in the different libraries and scales, and also the scales were differently important in different libraries, but this again was following a pattern that could be explained by the analysis of space.

It is herein presupposed, and shown, that, as argued by both Hillier and Read and Budiarto, movement and other spatial behaviour takes place in different scales. Movement through an entire building is movement of another scale than movement within one room (e.g., an office or a living room). It is not far fetched to think that these different scales of movement are affected by physical and spatial properties of different scales, which means that the spaces that need to be analysed are of different scales. Yet, they all exist simultaneously in a building.

It is here important to note, that the idea of the scales is closest to that of Read and Budiarto, and differs from “scale” as treated by e.g., local or global integration. It will be shown how, contrary to what the examples above may suggest, kinds of movements and scales of space are more complex to understand than the highly simplified notion of the given example. Scales and movements are not primarily dependant on the size of the space in consideration, like “a room” as different from “a building”, or necessarily how “far” the movement reaches, but rather based on what physical boundaries are important for the movement in question, and hence used to subdivide the building into a system of spaces in which to navigate. They all correlate to the spatial systems of the whole building. It is hence not a question of dealing with size of the system, but of the scale of physical reality that is used to delimit the spaces constituting the system for analysis through space syntax.
means.

What makes a building, in this context, different from a traditional European city like e.g. London or Stockholm, is that these scales co-exist and work within another in a much more complex way than in a city, making buildings more complex to analyse unless one is aware of this. This is a question I will return to, in the conclusion, since it first needs to be explained in what this complexity or problem lies.

2. The spatial scales

Following the reasoning above, four levels of detail - or four spatial scales - have been analysed in the research project. These have been named detailed, average, basic and conceptual spatial scale. The three first are the basis for configurative analysis within the standard procedures of space syntax, while the last is more a question of understanding the architectural concept of the building as space. In this paper, only the first three will be dealt with, since the fourth is rather of another kind. Understanding these scales and their effects is important not only for our understanding spatial behaviour, but to further develop our understanding of space in buildings - and to develop our understanding of how space participates in the production of meaning, which is the primary question of my research project.

The detailed spatial scale includes most objects taking up space related to movement. This includes furniture like tables, sofas, small bookcases and so on. Chairs are considered so easy to move that they are not included.

The average spatial scale is perhaps the most common one for space syntax analysis - it includes all objects blocking sight at normal eye-height when moving. This includes most freestanding bookcases, but not tables and such.

The basic spatial scale only contains built elements - walls, pillars, differences in elevation and ceiling height and so on. Pillars are, for the construction of the convex space graph, considered as two-dimensional - they split space in one direction. They do not create spaces between themselves - in the same way as doorways do not.

The spaces of each scale of concern for this paper are thus, as can be seen, constructed by physical boundaries of different kinds - and the construction of the spatial models...
for the individual analyses of each scale follow the established procedure of space syntax analysis - and are as a general rule based on analysis of the spatial systems of the entire building\(^1\). First, however, before delving into the question of the scales, both the libraries studied and the basic observations will be presented.

3. The analysed libraries

Before further addressing the question of this paper, it can be of worth to briefly introduce the buildings which have been studied. These are three public libraries that have gained wide acknowledgement as works of architecture, both from professional architects and the general public.\(^2\) The libraries in question, the City Library of Malmö, by Henning Larsen (addition to the library by Smedberg), the City Library of Stockholm, by Erik Gunnar Asplund and the City Library of Växjö by Smith-Hammer-Lassen (addition to the library by Uluot), all lying in or close to the centre of the city in which they are situated, are living parts of the city life and important landmarks of the respective cities.

A common theme of all the libraries is their clear exterior geometry - most often responded to on the inside. Each is composed of clear and simple geometrical forms in relation to each other - using the same basic components but arranging them in its own way. Stockholm is a cylinder in a cube, built after the established model of public libraries at the time of its construction (Winter, 2002). Växjö is a cylinder following half a cube, were the cylinder is added as a “[...]high-level geometry game, one worthy of a scholarly library, yet not out of place in its present more popular function.” (Lewan, 2003). Malmö, the “Calendar of Light”, is two cubes with a cylinder in-between arranged perpendicular to the entrance.

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\(^1\) As will be further explained, there are exceptions to this for various reasons. “The whole building”, however, refers to the publicly accessible parts of the building, as that is what constitutes the common spatial system for most people - just as the streets, squares and parks do in a traditional city.

\(^2\) The City Library of Malmö was awarded the Kasper Salin Prize in 1997, the City Library of Växjö was nominated for the same in 2003 and the City Library of Stockholm is one of the few Swedish buildings mentioned repeatedly in international publications. See e.g Trachtenberg and Hyman (1986), p. 556.
Figure 158: Exterior and interior photography and plan of the main floor, the City Library of Växjö (Photography: Runesson, H.)
4. The spatial analysis

The analyses have been performed in all three scales based on two models of analysis - axial line analysis and visibility graph analysis, while the convex space graph has primarily been focused on the basic and average scales. Each library was studied on-site under a period of several days, covering all of each library at intervals of two hours. The method used for the observation was primarily gateway studies using five-minute periods and snapshots - complemented by a few snail-trail studies for further understanding of the movement patterns.

The space studied was the publicly accessible space. Both in the axial and visibility analysis, spaces not open to the public have been excluded from the spatial model. Further, in all three cases, an addition of a fairly large exterior system is needed for correlations to appear. This might be caused either by the function of the buildings or by its situation in the cities. I propose, however, that it indicates more than that - namely that they in some ways work as extensions to the exterior system of public space. As being publicly accessible - available to everyone without any form of payment - they could in certain ways be considered part of the urban fabrics just as well as being treated as a set of spaces contained in a building.

Thus, the patterns of movements and how they relate to the spatial system of the buildings is reasonably different from a building primarily for those within the building - a private, or public, “contained” building.

5. Basic observations and correlations

5.1. Private reading and social interaction

The distributions of social interaction and privacy, as well as where people choose to sit down to read or study in a focused way tend to follow spatial properties in a number of ways. First of all, there is a tendency of the study places close to but not in the integration core being used much more than other places - even compared to those with “a spectacular view”. This is perhaps not too surprising, what is noteworthy, however, is that the choice of seating not necessarily is based on closeness to the literature that is to be studied.

Second, the study places closer to the highly integrated spaces are more often used for interaction - especially when there are small groups of study places that are somehow separated from other groups. Thus, interaction primarily takes place where discussions can be held with relative safety from disturbing others yet still close to the integration core. The studying places deeper (or less integrated) in the system have a tendency to be less used, relatively more used by single persons or smaller groups relative to the number of seats and for more private reading.

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3 This, at first, raises the question whether it is simply a question of correlation between movement and spatial depth, but it turns out that though the integration and depth patterns are somewhat similar, the correlations are highest compared to integration.

4 Something that is supported by the results of a parallel research project in the research group spatial analysis at the KTH School of Architecture concerning offices by Johanna Wiklander, Magnus Blombergson and Jesper Steen.

5 Something that has been observed in several snail-trail studies. It is, however, different in different libraries - in Stockholm, there is a closer relation between literary genre and seating than in Malmö or Växjö - something that may very well be a result of the spatial configuration itself.
Table 19: Malmö City Library, correlation between integration and observed movement.

<table>
<thead>
<tr>
<th></th>
<th>Basic Scale</th>
<th>Average Scale</th>
<th>Detailed Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial Line Analysis</td>
<td>65,8%</td>
<td>60,76%</td>
<td>49,7%</td>
</tr>
<tr>
<td>Visual Graph Analysis</td>
<td>32,3%</td>
<td>32,9%</td>
<td>32,3%</td>
</tr>
<tr>
<td>VGA, quadratic</td>
<td>50,9%</td>
<td>52,9%</td>
<td>51,4%</td>
</tr>
</tbody>
</table>

Aside from integration, there seems to be a preference for a fair amount of control, and perhaps more significantly, more control than controllability, both for the choice of place to sit and for where people stop to interact or just stand for one reason or the other. Adding to this, nodes of high control and high integration (and in the case of axial lines many intersecting lines of high integration) tend to produce both interaction and non-movement - as people often stop for a shorter or longer while at these nodes. In a simpler way of stating it, strategically important nodes for movement in the system also become nodes of spontaneous interaction.

Thus, observed social behaviour coincide with integration in a number of ways, supporting the results of the correlations found between movement and space - and also supporting the idea that by analysing movement patterns and comparing them to distributions in and of space (Koch 2004), we indirectly analyse the potential and resulting amount of social interaction.

5.2. Movement and integration

The analysis providing the highest correlation between spatial integration and movement, in all three libraries, is the axial map, and in all three libraries on the level of global integration. As a general tendency, the correlations are highest at the basic spatial scale, followed by the average scale and then with a rather large difference down to the detailed scale which has the lowest\(^6\). This even when the same observations are considered in the models and scales\(^7\).

The Correlations are around 50-55% in all visibility graph analyses, and between 50 and 65% for the axial maps. These correlation values appear when the observations at the entrance of the libraries are excluded, if they are included; the correlations reach up towards 80%\(^8\).

As stated, however, the correlations of the visibility graph analyses are also fairly good and thus, depending on what is sought after, can be of greater use, since they can say more about movement in a particular location. There is, however, in all three libraries, a strong ‘axiality’ in the patterns of movement produced.

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\(^6\) When constructing the axial line analyses, a max-max procedure has been used. That is, since in many cases several lines run through one gateway, and several gateways are covered by the same line, the most integrated line has been assigned the observation, and then the highest observation along this line has been chosen. Other procedures have been tested - such as medium integration per gate, with similar though slightly lower results in correlation.

\(^7\) Meaning that the only the gates existing in the basic spatial scale are included when measuring correlations in all the spatial scales.

\(^8\) The correlations, here given in per cent, are the R-square values calculated on global integration and observed movement.
Figure 159: Correlation scattergram, observed movement and global integration, the City Library of Malmö

Figure 160: Correlation scattergram, observed movement and global integration, the City Library of Stockholm (left) and Växjö (right)
6. Understanding the Spatial scales

At first glance, the fact that movement and integration correlates best on basic spatial scale tells us something of both the nature of (axial) space and of movement in the libraries. It seems like there is one kind of movement - or parts of movement - that is related to the basic spatial scale, where more detailed levels of subdivision do not really affect the choice of route. This, however, is more complex than it might seem. It is not simply a situation where analyses of more basic scales provide higher correlations, as might first be thought. In fact, analysis of movement in more basic scales, but performed in a system of more detailed scale, can provide even better correlations.

A case in point to introduce the discussion is the axial analysis of the spatial systems of the City Library of Växjö. When comparing the analysis of the detailed and average scale in this case, an interesting phenomenon occurs - in the detailed scale, two distinct parallel correlations appear (fig 161a) while in the average scale there seem to be only one (fig 161b). Two can seem to be existing, vaguely reminiscent of the two in the detailed scale, but not at all with the same clarity.

Studying the observations and their relation to integration closer, by investigating the spatial position and properties of each gateway, a pattern emerges where those observations with lower observed movement (per integration) belong to gateways which spatially are defined by objects existing only in an analysis of the detailed spatial scale, while those with higher observed movement (the upper line) are lines which run through gateways defined by objects belonging to either basic or average spatial scale.

Thus, it could be argued, the observations ascribed to the lower line are capturing movement in spaces specifically defined by the detailed spatial scale, while those in the upper are capturing movement that occurs in spaces that are defined by the average or basic spatial scale. This could, one could speculate, be applicable as a general phenomenon of levels of space and movement - thus different kinds of movements would actually take place in accordance with different spatial systems. And, hence, the different kinds of
movement within the same building should be analysed through different spatial models. It is important to note, however, that the movements and scales are not separated but rather interwoven - something that will be returned to in the following. Further, the scales would exist simultaneously in buildings and cities, where the one taking precedence would be the one corresponding to the individual movement performed. If this is the case, similar sets of several different correlations differentiated by spatial scale must be possible to find in the other libraries.

If we, hence, turn to the other libraries to investigate this, the same phenomenon occur, though less obvious. Beginning in Stockholm, where the question of to which scale each observation belongs is most easily answered, each gateway can be assigned as belonging to a certain scale, and then correlations can be calculated individually per each scale. Again, it must be stressed that the scales worked with are not taking different amounts of the buildings into consideration, but subdividing the spatial systems of the whole buildings analysed into more and less detailed systems.

It turns out that, actually, the correlations between observed movement and integration are higher for movements of both scales, when a more detailed spatial scale is used for the subdivision in the case of Stockholm (see fig 162a and b).

Turning back to the Library at Växjö, where the investigation began, and performing the same kind operation, the same pattern emerges. The two earlier found correlations appear, and they both individually have higher correlation values than the correlation of where all observations are not taken into consideration at once (fig 162 c and d). Important to note, though, that without taking the spatial scales into consideration to subdivide the observations in the more detailed analysis into different sets, the correlation is lower in the analysis of the detailed scale than in the analysis of the basic scale.

It also turns out that what gateways belong to what correlation is different in the Stockholm and Växjö cases. In Stockholm, the observations of gateways belonging to the average spatial scale follow the observations of gateways belonging to the detailed spatial scale.
Figure 163: Illustration of axial lines in the basic spatial scale (a) and their corresponding lines in the detailed spatial scale (b)

scale, while in Växjö the basic and average form one correlation and the detailed another. The basic scale, in both libraries, though not always having higher correlation, have a higher amount of movement than the detailed scale, with the average scale “joining” either the basic or the detailed scale. Important, though, is that all these correlations are to global integration - supporting the idea of space as allocentric, as suggested by Hillier (Hillier, 2003).

So, how are these scales interconnected? It must be said that what scale a gateway or movement belongs to is not directly transferable from plan to calculation. The axial lines existing in the basic spatial scale seldom directly exist in the more detailed scales. Thus some other means of finding corresponding lines must be found.

It shows, that the gateways, or axial lines, rather seem to belong to the scale of space in which they hold a strategic role for movement. Thus, in the City Library of Stockholm, when analysing the system based on average spatial scale, there are gateways which are defined by spatial borders belonging to the average spatial scale through which movement tend to belong to the system of the basic spatial scale. These gateways are always in positions where they are the reasonable route in the average spatial system in which to perform movements on the basic spatial scale. Thus, for finding the axial lines and observations belonging to the basic scale in an analysis of a more detailed scale, one must find what set of axial lines in the more detailed scale together form the route represented by the line in the more basic scale (As represented by the black lines in fig 163).

Finally, turning to the City Library of Malmö, the same phenomenon occurs once again - though a bit more complicated. The basic scale still separates itself nicely from the other scales, and thus far the pattern found earlier is found also in Malmö. The average and detailed scales, however, are more difficult to handle. Part of the answer to this ties back to the analyses of the systems of the City Libraries in Stockholm and Växjö, and will be further investigated in the following. Thus far, however, it seems that movement on all scales has a strong tendency to be dependant on the global integration, and that the
local movement pattern is related to the library as a whole, considered as a system of the scale in which the current movement is taking place. There appears to be, in all buildings, several spatial systems at the same time working in and through each other to produce the totality of movement patterns.

7. Spaces and metaspaces - relative scales and the organization of movement

In the City Library of Malmö, as stated above, the average and detailed spatial scales are more difficult to analyse. One reason for this seems to be the shifting role of the average spatial scale. Most clearly in the main hall the library is significantly different in its configurative character from the other parts of the library. In the hall, the objects defining the average spatial scale tend to have a freer relation to those of the basic spatial scale, at the same time as the difference in pure metric volume or size between the physical objects defining the basic and average scale is greater than in the other sections of the library.

When studying the movement patterns in this hall, some of them seem to follow different rules than in the rest of the library. Aside from the movement through gates belonging to the basic spatial scale, which follows the previously found pattern of correlating to the global integration of the building as a whole, the movement in the parts of the hall where the basic scale of space provide little or no support for movement this seem to not be the case, even when addressing it through analysis of other scales of space.

Rather than following the global integration in the system as a whole, the movement within the main hall seem to follow one, or both, of two basic rules. Either global integration in the hall based on visibility rather than axial properties, or a “next-node-connectivity” pattern in a convex space system. The latter meaning that each convex space seem to have the highest rate of movement leading from it into the adjoining convex space that has the highest connectivity.

Reasonably, this has to do with the complex spatial properties of the hall, and the conflicting configurative properties of different scales. A ‘system within the system’ emerges, where movement in the average and detailed scale to a higher degree than in e.g. the City Library of Stockholm shifts from interspatial to movement taking place within a space of the basic spatial scale - the main hall. Here, tentatively, there is a space of a basic scale that is dominant or defined enough to alter movement within it to movements within space. There seems to still be a configurative base for movement, but one based on convex spaces or visibility, and which has a tendency to correlate at the local level. The correlation seem to be either to the visibility graph as calculated ‘locally’ for only the second floor of the building, or to the radius two integration of the convex space system (or the connectivity of the next node). Again supporting an allocentric character of space.

Other parts of the library seem to follow the previously established pattern, where the average scale follow global configuration in either the detailed or basic spatial scale. This, together with the earlier observations, has further implications.

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9 Which also Read and Budiarto argue for (Read and Budiarto, 2003).
10 Radius two meaning integration calculated with a depth of two configurative steps (compared to e.g. radius three, local integration, calculated with a depth of three configurative steps.)
8. Concluding discussion

8.1. Conclusions on space

Thus, for the analysis of space in buildings, a thorough understanding of the scales of space in work needs to be developed. It proves that a number of spatial scales are working parallel to each other, or within each other, to produce the use patterns of the building. Further, space works on different scales in different buildings, where different scales become dominant depending on the design of the building - or how the distribution of space (Koch, 2004) is performed.

There also seems to be a basic tendency of how these scales interact. In buildings where the basic spatial scale provides enough support for orientation, such as in the Stockholm case, the basic scale also provides the primary spatial system in which movement takes place. In the case of Växjö, however, or the main hall in the City Library of Malmö, both open spaces of size, the basic scale does not subdivide space into entities providing enough support for overall orientation in the building. Thus, the importance of e.g. the bookcases reaching above eye-height grow, to a point where they are “defining” the spatial system in which people actually orient and move in, even movement that, formally, would belong to the basic spatial scale. The average and basic scale, in effect, merge into one. We can thus refer to certain scales of spaces as being the defining spatial scale of the system or subsystem.

Thus, the findings point towards differences in importance of both the architectural (building) solution and the interior design and furnishing solution for different kinds of spaces. Large open spaces are, quite understandably, thus more dependant on the interior design than the more rigid and enclosed traditional building - but the relative scales and their interaction goes further than that, and also work together in more complex ways.

What makes this different from a city, and both explains why this wouldn’t be found in the same way in urban analysis, is that in a traditional European city there is no doubt what scale is the defining spatial scale - it is the building scale, forming streets and squares. Most observations would be of movements of this spatial scale. In more modernistic areas, and many suburbs, however, a defining spatial scale is not as obvious, and it is possible that by understanding and analysing the interplay between different scales in modernistic areas, the spatial models constructed for space syntax analysis would look different, and possibly be correlating better to how space is cognized and used in such areas.

8.2. Conclusions on movement

What the key finding in this paper suggests - the coexistence of the three scales and their different but strong correlations to movement - is that when analysing (interior) space, one has to be clear of what scale it is one is working with. A mixing of observations from different scales may distort the analysis, and if not as clearly separated as in e.g. the case of Växjö but instead overlapping each other, it can be difficult to tell whether it is a case of low actual correlation or conflicting scales causing the low calculated correlation. It is possible that correlations that are fully existent and even strong are missed because observations that actually belong to different spatial systems are considered in the same analysis. It is also important what scale of movement it is one wishes to understand.

Hence, in the City Library of Stockholm, the basic spatial scale seems to be of primary importance for movement, while e.g. in the City Library of Växjö, the average scale seems
to be defining for movement to the same degree. The analyses of the two libraries thus need to be based on spaces of different scales, at least as far as movement is concerned, while the City Library of Malmö needs a more complex approach.

What is important, however, is that in all kinds and scales of space, movement tend to relate to the global system, or to a quite much larger system than the movement in itself would suggest, such as the entire new building of the city library of Malmö. Movement, further, seems to take place in as basic a scale as possible - meaning that when moving from point a to point b, the movement as soon as possible adapts to the system with least detail that still provides sufficient support for the movement to take place.

8.3. Implications for cognition and meaning of architecture

This fact, that movement is dependant on different scales in different libraries, further has impact on how the systems are cognized and how they, hence, produce meaning. It sets the role of the objects of different scales and reasonably, following the findings of e.g. Kim (2001) and Dalton and Bafna (2003) (See also Koch, 2004) how these are cognized and understood as well as what they mean. If e.g. the bookcases in a library is of primary importance to how I orientate in them - if they are distributing space - they will have another role than if they are objects distributed in a system of space. In one case, the books are subordinated in and ordered by a greater system, while in the other the books and bookcases are defining the system themselves. An interesting observation emerging from this is that it is not as easy as that the classifications grow weaker in the latter - in fact, it rather grows stronger. Since it is the bookcases and the books themselves who define space and relations, and not an overall system, the individual relations and positions of the bookcases and groups thereof grow in importance. This, however, is a question for another time.

Literature


