What Constitutes a Main Staircase? Ref 011

Evidence from Wayfinding Behaviour, Architectural Expertise and Space Syntax Methods

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Abstract
The present paper investigates a couple of design solutions in a realistic design scenario having regard to underlying design rationale. The development of appropriate evaluation criteria for candidate design solutions raises a fundamental question: How to operationalise 'main-staircase-ness'?

The researchers make their own work to their subject of investigation by analysing the course of arguments during the development of an evaluation study. Ideally, evidence-based design evaluates and improves design solutions based on independent empirical investigations. The present study, by contrast, shows that design solutions and evaluation criteria are inevitably interwoven. As a consequence, the set of considered design solutions is strongly influenced by the logic of empirical research rather than vice versa.

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1 Introduction

Wayfinding and navigation issues have been an issue for architectural design as well as behavioral and cognitive science. (See Evans and McCoy (1998) for an overview.) Weisman (1981) is one of the first to make considerable steps towards a scientific investigation of Architectural properties which foster wayfinding friendly building designs. Our research aims at the systematic investigation of architectural properties that shape navigation behaviour and wayfinding cognition. An early study (Hölscher, Meilinger, Brösamle and Knauff 2006) followed this research logic and asked participants to find six locations in a complex multi-level conference centre, located in Günne am Möhnesee, Germany. (See Figure 1) The focus of these early studies was very much determined by the question, why many buildings are well-navigable while at the same time others fail spectacularly without beeing clearly more complex or revealing another conspicuous property. The Günne conference centre is a good example for these intriguingly complex buildings: While architectural designers often do not spot orientation issues spontaneously users frequently complain about difficulties in finding their ways even in everyday usage.

Based on wayfinding behaviour, debriefing interviews, and informal analysis Hölscher et al. (2006) identified a number of architectonical properties that they considered responsible for the naviga-

tion difficulties. Brösamle, Vrachliotis and Hölscher (2007) substatiate the results by identifying characteristic configurational properties related to each of the previously identified usability 'hot spots'. In the light of the analyses most usability issues appear comprehensible such as the lack of visibility of navigation options or staircases or dead ends in circulation relevant areas.

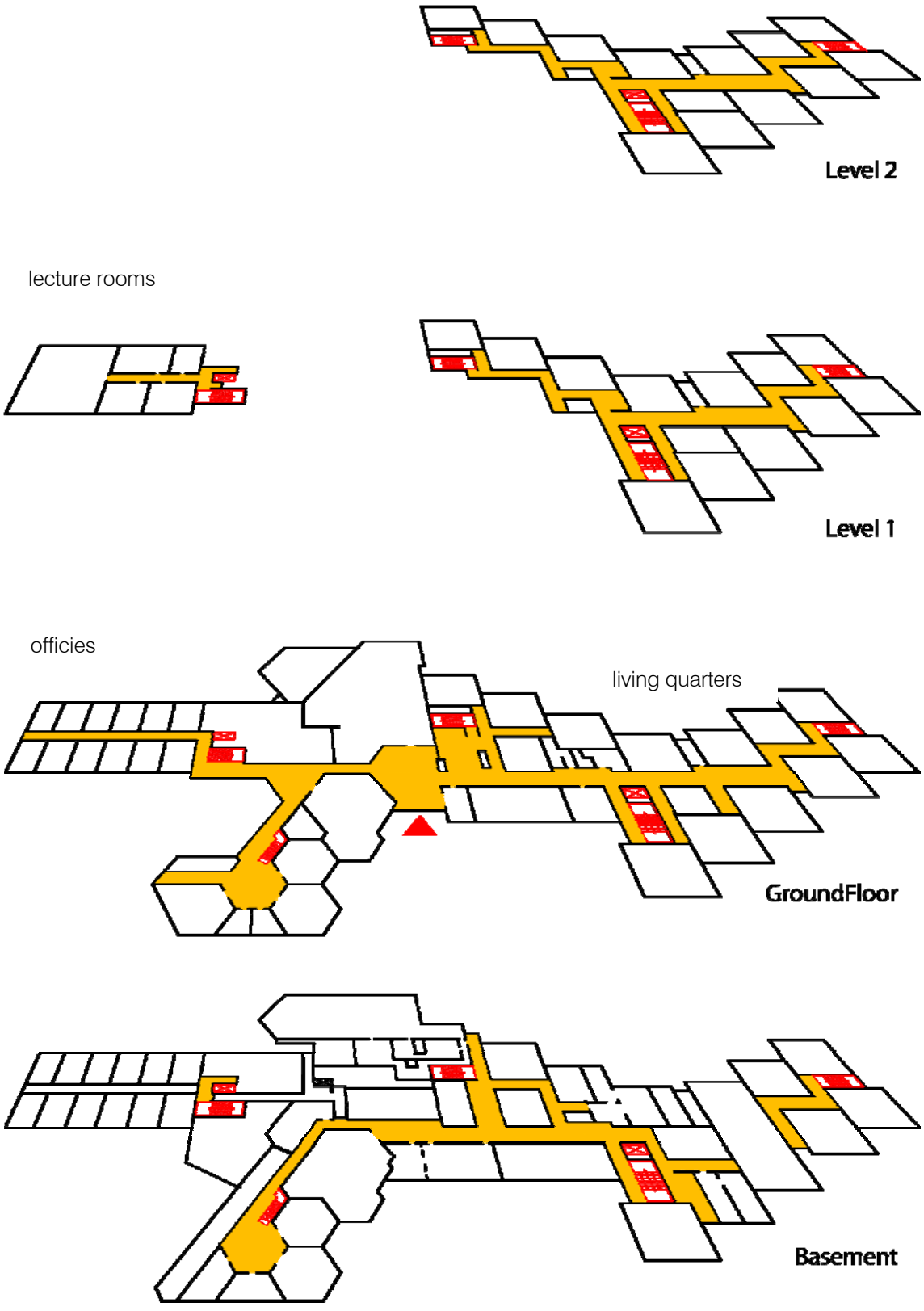

Figure 1
The Conference Centre in Günne, Lake Möhne, Germany.

Less obvious is the phenomenon that the building seems to fail to communicate a clear main staircase. The first piece of evidence comes from the debriefing interviews of the initial study, where users complained about the absence of a clear main staircase. Analytically this finding is reflected in the results from Visibility Graph Analyses (Turner et al. 2001) which analyse each floor separately. (See Figure 2) In the lower floors the foyer stairs (left in the figure) is more integrated than the stairs close to the living quarters (right in the figure). By contrast, in the first and second floor the pattern switches such that the living quarter stairs is the more integrated. Brösamle et al (2007) conclude that the role of the staircase is different in different floors, namely, for the upper floors the living quarter stairs is most important while the foyer stairs is most important in the two lower floors. In the light of this analysis it is not surprising that users have difficulties in deciding which one to consider as the main staircase.

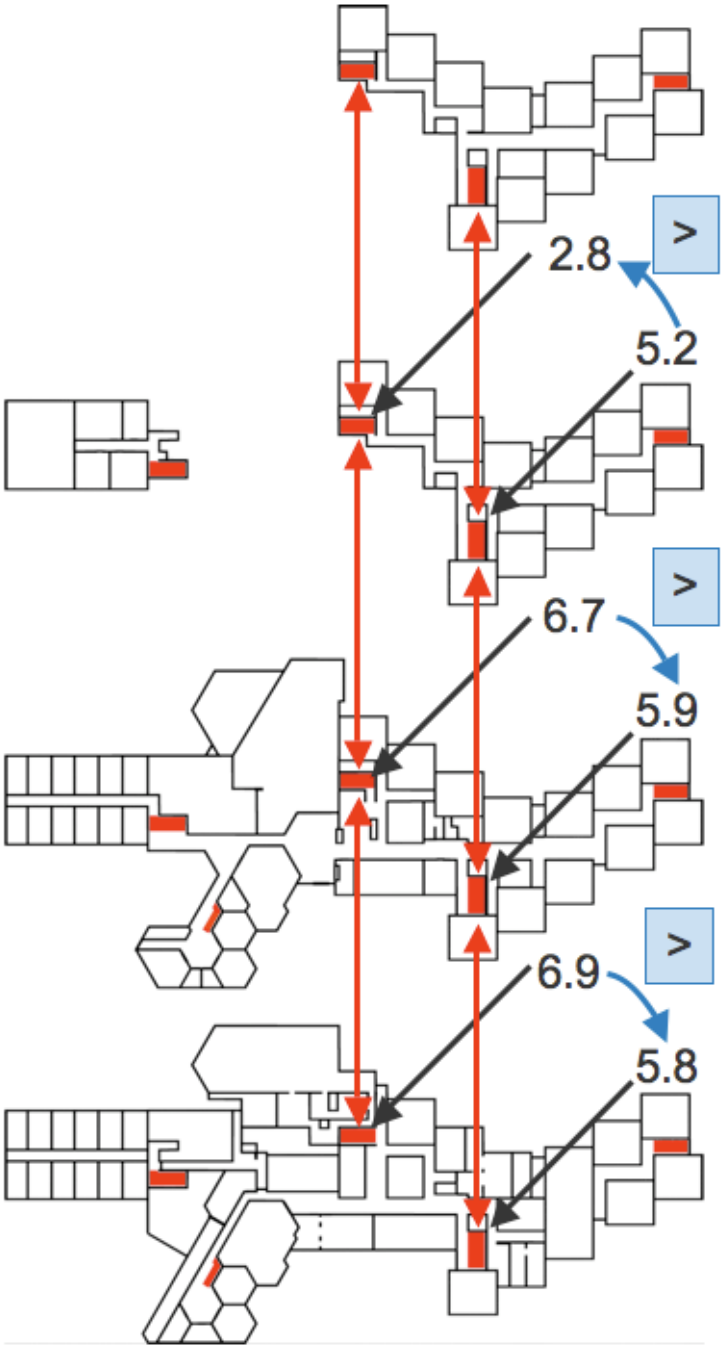

Figure 2

Integration Values of two Staircases. The Values are based on separate analyses for each floor. While in the lower floor the staircase in the Foyer is more integrated whereas in the upper floors the pattern switches such that the Stairs in the Living Quarters is more integrated.

The question 'What constitutes a mainstaircase?' is representative for the question what are the ingredients of good architecture.

1.1 Measuring Main-staircase-ness

To actually measure the quality of a design solution implies to agree on certain criteria of evaluation. Based on the argumentation of Brösamle et al (2007) a straight forward way to measure mainstaircase-ness would be to look for the most integrated staircase with respect to the horizontal layout. The underlying argumentation is that the subjective lack of a main staircase is reflected in the ambiguous integration pattern of the two central staircases. An other line of argumentation would emphasize functional requirements like the staircase that best connects all floors. Here, number of shortest paths between origin destination that use the staircase in could be an adequate measure.

A psychological approach would be centered around the acceptance of a staircase as a mainstaircase by users. To assess this subjective acceptance participants could be asked, which staircase they consider as most important. (The way to ask the question would of course influence the outcome in certain instances.)

Wayfinding Design (Passini 1996) clearly would ask how to communicate to people which navigation options are provided by a certain staircase, namely which functional areas are supported by it. An evaluation could ask participants to search for certain locations in the building and then see whether the design causes detours or wayfinding errors.

As can be seen from the above aspects there is a degree of freedom with respect to the underlying design evaluation criteria which results from the expectation towards the design solution. At the same time there is a degree of freedom with respect to the actual performance measurement: One can measure wayfinding usability by asking people for their impression of the clarity of a solution or one could test whether they actually get lost. The two degrees of freedom look, at first, independent. The reminder of the paper will argue that a design solution and its evaluation is strongly connected and that this has serious consequences for design research.

1.2 Investigating the Logic of Empirical Research and Evidence-based design

Following the logic of empirical research and of evidence-based design the next steps to address the issue would be to modify the problematic parts in a systematic, theory-driven way and then test whether the design performance changes in line with the expectations. In principle, a certain body of theory directs the design modifications as well as predicts the outcome of these modifications. The empirical researcher of course wants to test the applied design principles by evaluating the respective outcome in the light of the expected outcome. The present paper presents only the first step of the scientific process: the systematic modification of the existing design and the development of its evaluation study. At the first glance this looks like leaving aside the most interesting part, namely the empirical results. However, as it turns out, modifying a design is by far more complex than simply permutate the values of a couple of variables as it is often done when creating a set of systematic stimulus variations for a typical psychological laboratory experiment. There is a much larger number of variables in a typical design problem. Moreover, there are many ways of conceptualising (shaping) the same problem (or solution) where each instance describes the problem with an other set of concepts and variables. (Goel & Pirolli 1992). Because of the above characteristics of design problems, it is seldom the case that only one design principle is applied separately. The holistic character of design is well illustrated by the idea to optimise one artefact according to a large number of requirements. (can we find a reference for to argue that design is 'holistic'? At the same time, empirical research is by virtue analytical: Single effects are separated from the polyphony of phenomena and stabilised (=made reproduceable) in laboratories under controlled experimental conditions.

For these reasons, the design solution very much depends on the conceptualisation of the problem. In the same way the evaluation depends on the way the problem, and the solution is conceptualised. Thus, the degree of freedom with respect to the criteria of a good solution influences a large number of variables shaping the design solution. At the same time the evaluation will depend on the very same criteria of good design.

With this in mind we can now decent to the catacombs of interwoven dependencies between design generation and scientific analysis. This is where holistic design and analytic research will meet … and this is where they will reveal their mutual incompatibilities.

The present paper will follow the course of arguments between the three authors while developing design variations of the Günne conference centre. At the time of the sessions, their aim was to use the systematic variations and their empirical evaluation as a vehicle to reveal design principles which are capable of producing good solutions. The present paper, however, makes this piece of research activity practice to an object of investigation: A couple of design sessions addressing the main staircase issue serve as an illustration how the scientific rationale finally influences the design logic instead of neutrally investigating design rationale.

2 Methods

The present study analyses a discussion between 'Architecture' and 'Science' during the development of an empirical study for to investigate wayfinding friendly design. The three authors – each of them trained in a different profession (Cognitive Science, Architecture, and Cognitive Psychology) – discussed the Günne conference centre as a design case having regard to wayfinding cognition and usability issues.

The aim of the discussion was the development of design interventions according to certain criteria: First, they should derived in a systematic and comprehensible way based on the existing analyses of usability issues. Second, the resulting design variations should be tested and compared to the original such that the used principles could be evaluated.

The discussion was sub-divided into three sessions: The first session focused on the exploration of potential design solutions. During the second session, the focus was shifted towards the development of wayfinding experiments for the purpose of design solution evaluation. The third session refined the previously developed design interventions and produced drafts of sufficient level of detail, such that an architect would be able to create and modify a 3D model of the existing building in accordance with the design intervention.

The sessions were structured as expert interviews – the Architect taking the role of an interviewed expert while the two Cognitive Scientists took the roles as interviewers. While the Architect was responsible for working on the design modification itself, critical questions from both Interviewers forced the informer to explicate assumptions, principles, design rationale and so on. In a later stage, the scheme was shifted from the strict interviewer-informer-type of dialogue towards a collaborative discussion. All sessions where video recorded such that verbal utterances could be transcribed as well as gestures and drawing marks be reconstructed.

The lines of argumentation are reconstructed based on the documents available. The data would allow further, more formal analyses (Suwa, Purcell and Gero, 1998) However, the differences and incompatibilities between both professions easily become obvious on a citation basis. (Double quotes “ ” indicate direct citation from the transcripts whereas single quotes ‘ ’ indicate special words, informal expressions or the like.)

The following section will follow the course of arguments within the sessions and on this journey present the potential design solutions. The second part will focus on the scientific arguments dealing with issues of evaluation and empirical investigation of design principles.

3 Exploration of design solutions

3.1 Spontaneous re-designs

For a series of interviews in a previous study (Brösamle & Hölscher 2008) the Günne conference centre served as an example case. When evaluating the building with respect to wayfinding optimisation, some of our informers produced drafts for re-designs of the building that they expected to be superior to the original building in terms of navigability. These ‘spontaneous’ re-

designs were the first step towards a systematic development of design interventions. The fist set of design interventions follows almost directly from the previous analyses (which we provided to our informers within the course of the interviews).

Most informers suggested to improve the visibility in the entrance area and make the adjoining staircase directly visible from the outside.

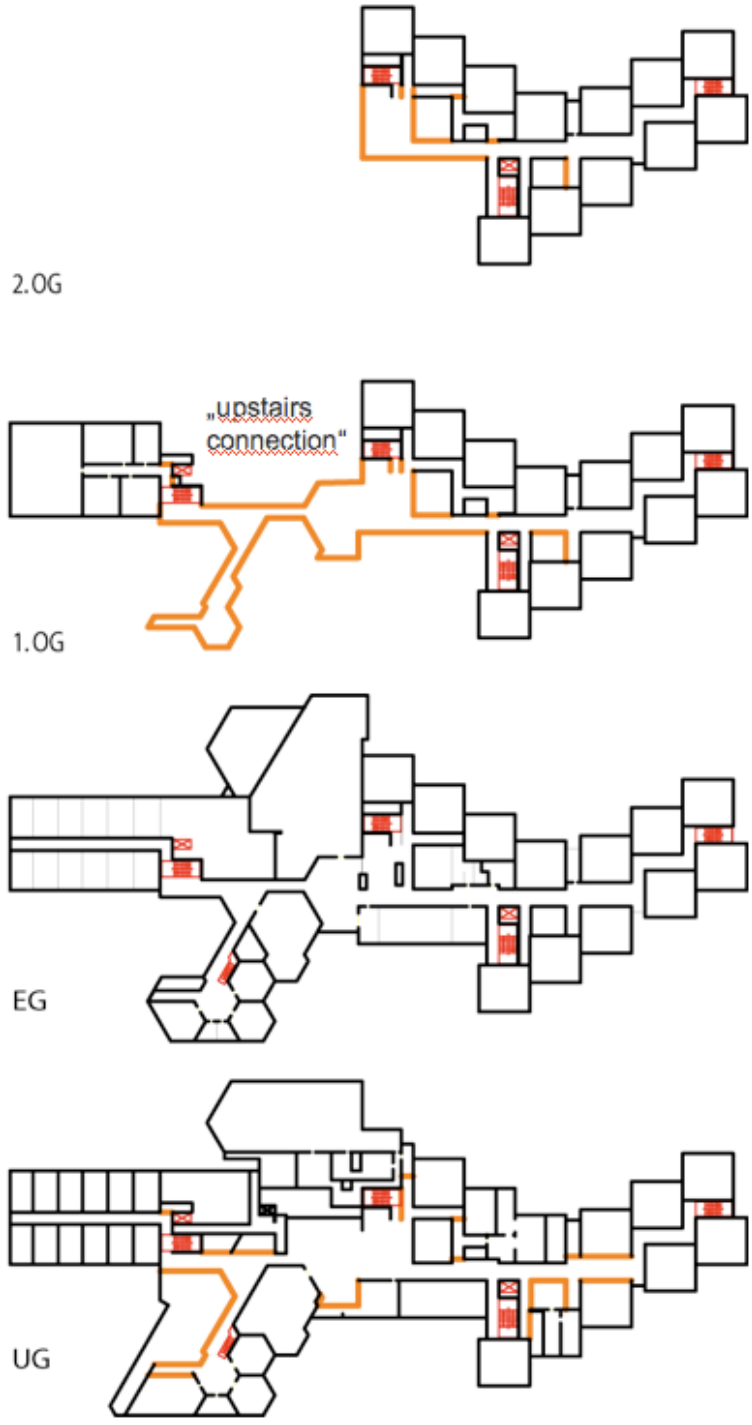

Figure 3
The design variant ‚congruent floors' makes the floorplan layout match between different levels.

Other solutions are based on the non-congruence of the different floors. They either intent to make the ground floor similar to the basement such that the integration between floors can be improved (Soeda, Kushiyama, and Ohno 1997) or to simplify the basement's layout so much, that a

confusion (=deficient integration) between basement and ground floor is no longer possible (Brösamle and Hölscher 2007).

Based on the spontaneous re-designs and the preceding analysis the most obvious improvements, which directly follow from the problem analyses, are to bridge dead-ends and make floors more similar by making a connection in the first floor (see Figure 3). Independent of how complex or simple these layout oriented interventions interventions are, they can be characterised as closely related to the spatial structure of the building. The underlying design rationale is based on layout, configuration and visibility properties. For this reason, the analytical evaluation is relatively straight forward. Solutions of this category were developed relatively early in the course of the present interviews. They included interventions like widening corridors, moving staircases towards more visible locations, straightening zig-zag-turns and so on. The underlying reasoning is always about making crucial parts easily visible from key points (like entrances or foyers) or to provide overview in important areas. Figure 4 shows a design variation which is primarily based on such interventions.

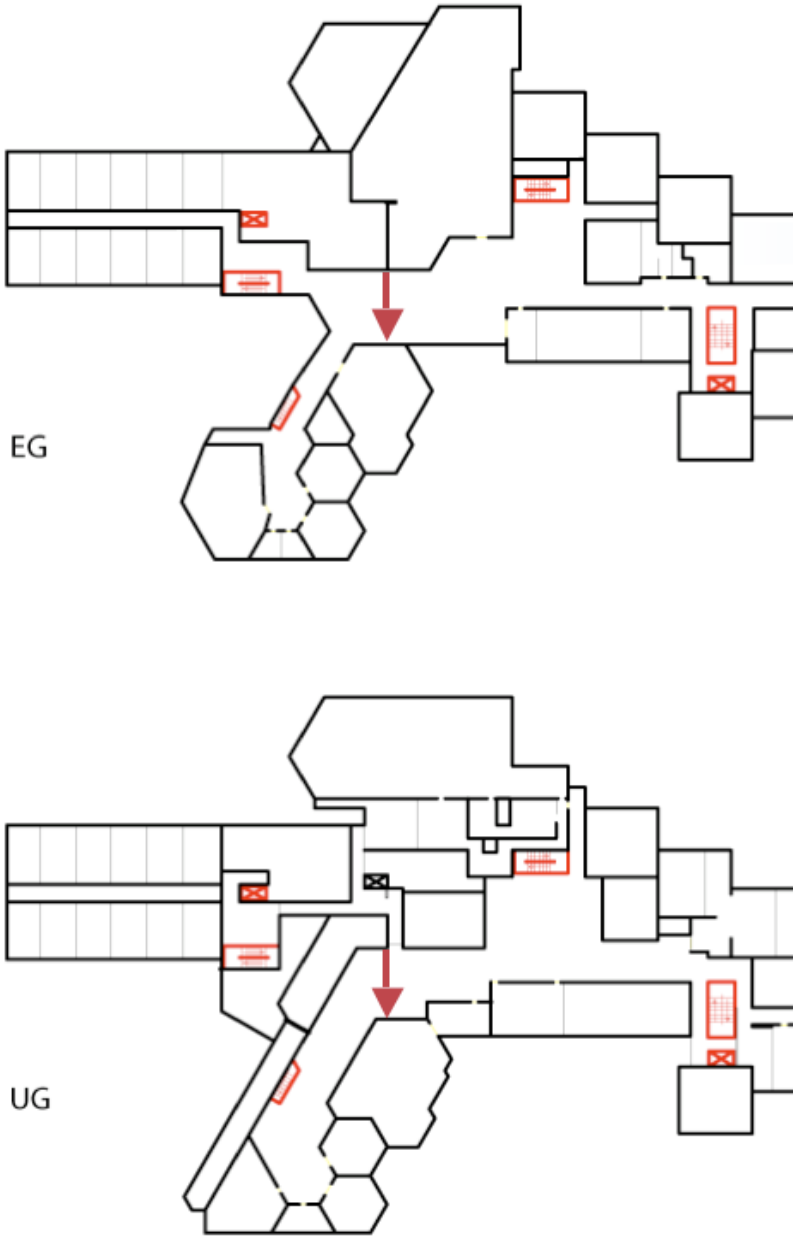

Figure 4
This design variant is primarily based on layout-based, 'syntactical' interventions. E.g. corridors are widened and staircase locations are changed, such that they improve visual access.

A much more “invasive” solution, which directly addresses the main staircase issue, puts an atrium in the foyer. (See Figure 5) The staircase would become easily recogniseable as the central staircase. At the same time, the upper floors are well connected with the ground floor entrance area.

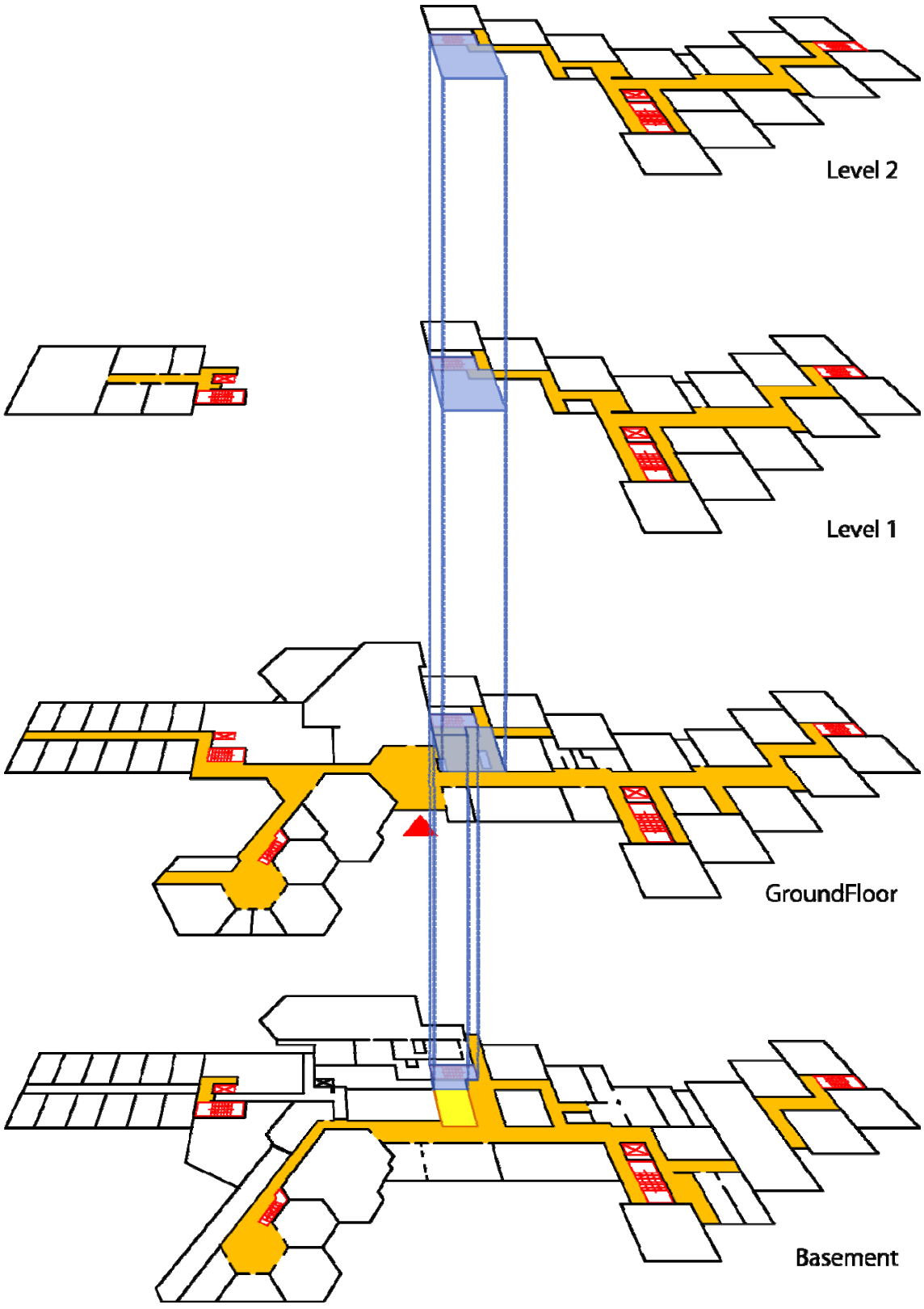

Figure 5
The design variant introduces an atrium into the intrance area.

An alternative to the atrium makes the staircases easily recognizable by straightening the corridor in the first and second floor. Similarly, the corridor could be re-organized into an L-shape instead of the zigzag-turns. The recognition of each stairs would be facilitated simply by giving more overall visibility in the corridor layout. While the latter two solutions are the more elaborate instances in the layout-based category, there is another intervention which is in principle the most direct cure of the identified integration pattern in the separate floor analysis (see Figure 2). The difference in the integration pattern between the two upper floors and the two lower floors was seen as a resulting from an "in-balance" in the building. To re-balance the upper floors, a connection between the lecture room part and the living quarters in the first floor was suggested;

S: "*So one of the reasons why we naively thought of making this connection upstairs on the first floor was to give it more balance."*

It is not surprising, that this solution was suggested by the Scientists party (S), which also made the related analysis.

3.2 Functional aspects

S: *"You were not so fond of the idea of making a connection upstairs?"* A: *"No. I think with the existing layout, it wouldn't help that much. It would help, but not that it would make a big difference. It would make more sense and much more difference if the functions were shifted, especially if the offices were upstairs and the lecture rooms downstairs, so there's no need of connection because this [the offices] would work totally independently, function-wise."*

As we can see, the Architecture party (A) suggested to re-arrange functional areas instead of making connections between "two spaces [that] have different function". The underlying design rationale is no longer primarily primarily layout driven but emphasises function as a second aspect:

A: *"It's a relation of the function and the layout of the building. It should not be looked at only as a layout, but because it has a function as well, the function should be taken into account rather than – the function can help the mapping of the layout."*

The previous analysis were based on space syntax methods and Visibility Graph Analysis (VGA) and thus triggered a spatial, configuration-centred approach to the problem, such as equalising floor layouts in a copy and paste style. In a way, the problem was identified syntactical and the attempt to solve it was also syntactical. What is expressed in the above citation is an approach which re-thinks the problem as optimizing the correspondence between spatial and functional characteristics and connections.

Applied to the main staircase problem, this leads to the idea of a 'private' and a 'public' staircase by arranging functions 'horizontally' and 'vertically' into areas such that there is "one staircase per block".

3.3 Cognition of Function

With respect to usability, the previous idea of "how […] [to] assign specific functions to layout" has a cognitive component:

A: "*[People] are not all equal as users […] it's even good to have spaces which are not equal and are not grasped by everyone the same way, so you want to have different understandings of the building by different users."*

The concept of "visitability" nicely condenses the troika of functional, spatial and user group aspects. At the same time the holistic character of design becomes obvious. The reminder of the paper will argue that this very property of design lets fail classic cognitive science when analysing architectural design solutions.

4 Evaluate Design Solutions

The most pressing question for an evidence-based design approach is to know whether a solution is good or not. When is a staircase a good main staircase Scientists would of course want to find a

general criterion that can be used to test all staircases in the world for their degree of 'main-staircase-ness' – like a litmus test. Following from the overall challenge – to produce navigation-friendly designs – a reasonable criterion for the course of the present study would be whether or not people are able to grasp one important staircase as a 'main staircase'.

However, the scientific interest of this paper does not only intends to design and test main staircases but also understand how architectural design succeeds or fails to produce them. More specifically the question is which design principles are capable of producing good main staircases not only by chance but by useful procedures or a-priory criteria. Knowing which approach leads to good main staircases would in turn tell a lot about the crucial architectural ingredients of a good (=easy to grasp) main staircase. The idea of the original study was to produce a set of design solutions according to some criteria of interest and then test them empirically.

This section will now have a look at how different design solutions could be evaluated and how these evaluation studies were developed within the discussion between Science and Architecture. The graspability criterion of main staircases fulfils the is universal in the sense that it can be applied to every existing staircase. The only thing to do is to ask the users. However this is not a practicable solution to for planning. Ideally, solutions could be tested easier in beforehand. And this is the point where the evaluation criteria no longer are independent of the aspectualisation of the design problem and solution.

For the floorplan equalising solution both parties agreed that it was a much better solution than the original – under a pure layout point of view. Also, there was little doubt that the improvement would easily be demonstrated by controlled wayfinding experiments.

S: *"If you think of the hotspot, the hotspots that we have tried to describe in our previous paper* [Hölscher et al. (2006)]*, none of them have anything to do with semantics. They were all very much about the geometry of surveyed places, and staircases and connectivity and stuff.* […] *I mean, all that would be interventions that should reflect well in a way finding experiment* […]*"* A: *"I think it would be important to differentiate the tasks […] based on the layout and based on function.* […] *or you can simply say that we're testing only the layout and we don't care about the function* […] *You do solutions which improve the layout."* S: *"But we cannot really test this. I mean, okay, we can test it without giving any semantic tasks to the people."*

At the same time, testing layout interventions should would have to be tested with tasks that do not refer to functions in the building. This is especially true for the labebels of target locations, as expressed in the former interview passage. Functional and semantic aspects are degraded to a variable to be controlled. Frequently, for the testing of pure layout variations, the necessity to "control for function" by using "artificial arbitrary landmarks for marking destination points" or even to "strip off" the "functionality of the building" is raised.

By contrast, an attempt to develop an experiment to test solutions with respect to functional criteria was only sketched but never developed in detail.

A: "[…] *you would assign your functions according to the level of visitability you wanted to have."* S: *"Which means we cannot easily test this in VR* [virtual reality]*."* A: *"You can test the layout, but if there are no functions, then you don't –"* S: *"So we don't test the actual building, how it is working in place, but we are only testing parts of it?"* A: *"Yes."*

While the syntactic solutions were considered as easily testable the functional aspects, by contrast, appear to be hard to test under laboratory conditions. This marks the aspectual bifurcation not only in the design rationale but also in the rationale of experimental testing. In other words, layout-based design interventions reveal their strengths under different testing conditions than function-oriented design interventions. This contradicts the idea of a general purpose litmus test for good main staircases. It is at odds with the very fundamental idea of analytic science: To find simple elementary processes or mechanisms to explain complex phenomena.

At the same time, Architecture emphasises the inseparability of the functional aspects from the theme of navigability:

A: *"navigation and way-finding is not simply about layout or simply about function, but it's about both these things."*

This holistic view does further complicate the evaluation of design solutions. It becomes evident that scientific methods tend to be strongly focused on only a few variables. In a similar way, the following argument wants to focus on only the layout aspect in for an experiment while excluding the functional:

A: *"I think actually this thing with the – that's what I was thinking, the function and the layout is getting – it's actually two different things, and you cannot – maybe you have to focus only on one of them in this experiment, like only the layout, and exclude function* […]*"*

To the cognitive scientist, the systematic investigation of multi-aspectual solutions appears to be an almost insolvable difficulty. While this property underlines the 'holistic' character of design it is a burden for the cognitive scientist who wants to reduce things to simple elementary processes:

S1: *"Well it would be elegant if we could show in a cognitive – and as cognitive I mean non-semantic but structural way –"* A: *"Isn't it where semantics part of cognitive –"* S1: *"Yes, but then it's –"* A: *"It is, isn't it?"* S1: *"– always about content, and the theory is that we want to have a content _____ about process and –"*

S2: *"The basic idea in cognitive science is that there's a process and there's content in processes."* S1: *"Yeah, and what we're interested in is the type of content and the process, but we're not interested in the individual content. We're interested in types of content because we are not always asked about _____ structures. So is it pictures or it descriptions of pictures that are being processed? That is a comment _____ but then we had this picture of cars, over there there's pictures of bees _____."* S2: *"Yeah, and if you take the whole thing serious about the brain, the content and the process is not _____ and you have a big, big problem with our model, and also you have a big, big problem with the model understanding _____ because there you always have content."*

S1: *"*[…] *– for the theory of how a simple processing system works, it doesn't matter what the symbols mean."* S2: *"Yeah, but I don't think that our brain works like that."* S1: *"How else would it work?"* S2: *"That's the whole – yeah, I mean look at connectionist models. You don't have explicit symbols there, and you can't put people into architecture without having them understand some semantic issues. You will always have them. They will always think of something _____ –"*

A: *"In many cases, yeah, architecture is very related to semantics. I mean you cannot get rid of it.* […] *You leave this aside, but then it will be just part of it."* S2: *"Yeah, that's what you experience when you try to put architecture in a laboratory. You can't do this with the basic processes like how long _____, but we have big, big problems. Since we are doing this, we should research on architecture. We have big problems in figuring out good experiments in the laboratory, and I think that's why – that's because we have always to do with complicated content, and we have no models to deal with that so far. That's why* […] *struggles to give us useful architecturally plausible manipulations that do not have to do with function.*"

This last passage illustrates well the difficulties of investigation a phenomenon as big and as complex as architecture using a theory that is as elementary and reductionist as the symbol processing model of cognitive science. Goel (1995) expresses a similar concern with respect to classical processing models design problem solving research. These incompatibilities between research paradigm finally propagate back to the design solution to be investigated.

In the course of arguments outlined above, this is reflected in the fact that the transition from the first phase (design variation) to the third phase (develop an evaluation study) also marks the final

decision in favour of layout-based design variations but against functionally modivated variations. In a sense, the logic of the laboratory has re-directed the course of the investigation away from the original question. 'What constitutes a main staircase?' was re-fomulated as 'Which aspects of a main staircase can be tested under controlled conditions?'

5 Discussion and Outlook

The above discussion shows that there is still a considerable (if not principal) gap between reductionism of analytic science and practically oriented "holistic" design. The attempt to put design solutions under close investigation is an important enterprise within the scope of evidence-based design. However, it is still an open question whether the laboratories of cognitive science are the best tool to achieve this. The impulse to reduce a design solution to its layout illustrates the immense difficulties in the methodology. For example it is common practice to use arbitrary landmarks (Janzen 2006), which was introduced in the above discussion to "strip off" the semantics of a building. This demonstrates that characteristics of research instruments have an influence on how we operationalise mainstaircase-ness and finally which design solutions are considered in the research.

Our research will continue with the techniques and theories available today. For example, we will investigate the developed design variations under experimental conditions in a Virtual Reality laboratory. But at the same time, the above course of arguments shows that we have yet some progress to make before we can re-produce the essence of good design solutions under conditions of scientific investigation.

Acknowledgement

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