Focalizing Measures of Salience for Wayfinding

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Abstract. This chapter reviews a model of measuring the salience of a specific class of spatial features—façades of buildings—for adaptation to abilities and preferences of user groups of wayfinding services. The model was intentionally designed to be open for such adaptations, and we will report on ways, experiences, and limitations of doing so. We will prove the hypothesis that focalization, i.e., adaptation to different decision situations, can be sufficiently modelled by weights of predetermined salience measures to increase wayfinding success. The long term goal is to identify sets of weights for typical foci of user groups.

1 Introduction

Navigation services calculate routes and present instructions to follow such routes to the user in a geometric format. A typical example might look like this: “Take Street A and go/drive for 150 m; turn left to Street B and go/drive for 70 m; …” Communicating wayfinding information in such a way is not intuitive for the user. Research in spatial cognition has demonstrated that people use landmarks during spatial reasoning and communication of routes [5]. It is therefore necessary to integrate landmarks into route instructions to enhance their user-friendliness and cognitive plausibility.

Recent work has shown a way of automatically extracting salient features from datasets and using these landmarks to enrich wayfinding instructions [16]. The model of landmark saliency is based on three categories of attraction measures, i.e., *visual*, *semantic*, and *structural*. A case study in the city of Vienna was used to demonstrate the applicability and usefulness of the method. Subsequent work included human subject tests to prove the cognitive plausibility of the model [14].

This model described a *general* approach of measuring the salience of features but it has been applied to a limited case only, i.e., a specific user group (pedestrians in a dense urban environment) travelling in day-light and using specific features (façades of buildings) as landmarks. In principle, the model can be expanded and refined by applying it to different user groups, features, travelling modes, and environments. The goal here is to investigate the fit of the model to different user groups.

People in different decision situations focalize on different elements in their environment, i.e., the ones that are relevant to their individual decisions [see also 25]. This chapter tries to map people's focalization to the proposed measure of salience. This measure of salience selects features assumed to be in people's center of attention during wayfinding situations. It was developed with the option of being adapted to different wayfinding concepts by modifying the component weights of the global measure of landmark saliency. Here we investigate this possibility through experiments with human subjects. These tests focus on people's landmark selection during wayfinding by day and night, and on the differences in measures used for the two conditions.

Section 2 explains landmark-based wayfinding and the measures in the model of landmark saliency under investigation. In Section 3 the notion of focalization during route finding is described. Section 4 investigates the possibility of representing different focalizations through weights of salience measures. In Section 5 we present the study conducted to investigate people's selection of landmarks under different conditions. Its results are discussed in Section 6. Section 7 presents conclusions and directions for future research.

2 The Measure of Salience

Landmarks are inevitable means for people to memorize and communicate route information. Hence, automatically generated wayfinding directions could be improved in their cognitive accessibility by the use of landmarks. However, there is no formal definition of landmarks so far. This section summarizes an approach to quantify the *landmarkness* or salience of a feature, based on distinct qualities. Quantifying salience, the most salient feature in a neighbourhood can be identified and used in a wayfinding instruction.

Human wayfinding and landmarks are discussed more extensively in [15, 16]. Wayfinding is the process that takes place when people orient themselves and navigate through space. Wayfinding behaviour is considered as purposeful, directed and motivated movement in large-scale space, i.e., towards a destination that cannot be directly perceived by the person. We further assume that the route to the destination is unfamiliar to the wayfinder, i.e., she needs symbolic information about the route to take. Here, we concentrate on landmark-based piloting where the success of wayfinding depends on the recognition of landmarks and the correct execution of the associated wayfinding directions. Landmark-based wayfinding instructions are the natural choice in human communication of routes [3, 5, 10, 12] because they are cognitively easier accessible than instructions based on distances and directions only [4, 7, 21].

Landmarks support the building of a mental representation of an advance model of the route. Landmarks can be located at decision points of routes, along route segments, or distant from the route. People use landmarks preferably at decision points; distant landmarks are exploited only for overall orientation. Lynch [11] characterizes landmarks by their singularity, or contrast to the background, which is a concept from Gestalt theory [22]. Sorrows and Hirtle propose to distinguish three qualities of features that can contrast to their neighbourhood: visual qualities, cognitive qualities, and structural qualities [18]. This slightly modified classification is used by Raubal and Winter to propose sets of measures for these qualities for an initial class of features, i.e., façades [16].

In this model, the visual qualities of façades are captured by measures for the façade area, shape, colour, and visibility. A façade is considered as visually contrasting or salient if its area, shape, or colour differs from the façades in its neighbourhood, or if its visibility area is larger. Semantic qualities are captured through measures of cultural or historical importance, and through the identifyability by marks (e.g., signs). A façade is considered semantically salient if it reaches high measures compared to its neighbours. Structural qualities are not defined in this model, but left open for other feature classes.

The overall salience of a façade is computed by a combination of the individual measures. For this reason the individual measures of a façade need to be scored against the distribution of each measure for all façades in the neighbourhood. The statistics for scoring is described in [15]; it is not trivial because of skewed measurement distributions with means close to zero, and deviations from the mean in both directions considered salient in some cases. For instance, façades with a relatively large area might be considered salient ("huge building"), but also ones with a relatively small area ("tiny hut"). The total score for a façade is the weighted mean of the individual scores of its visual and semantic qualities.

This model was implemented and tested for some street intersections in Vienna [15]. In the test, automatically identified most salient façades were compared with human choices from panoramic photographs. Being short of other evidence, the individual measures of a façade were aggregated with equal weights to a subtotal for visual and semantic qualities, and then further to an equally weighted overall measure of salience. Note that this way a single visual quality weights less than a single semantic property, having five visual, but only two semantic measures. However, the tests showed a high correlation between the automatically selected and human selected façades, even in the ranking. The model—chosen measures and their equal weighting—seemed to be cognitively plausible for the given situation.

The set of measures was later extended to include a route-specific visual quality, i.e., *advance visibility* [23]. According to this proposal, the selection of a façade depends on two qualities—its overall salience and its advance visibility along a route. For a street intersection in the course of a route the system selects a façade that is at the same time relatively salient and early visible for the advancing traveller, instead the most salient which might be not visible until approaching the intersection. Advance visibility is introduced as a compound measure of route coverage of the visibility area, and orientation of the façade with respect to the direction of the approaching traveller. This extension of the model could also be proven to be cognitively plausible, and superior with regard to wayfinding success compared to the original one.

Other approaches to identify salient features are reported by Burnett et al. [2] and Elias [6], the latter being influenced by the model described above. Zipf [24] proposes a function for the relevance of features for focus maps. The function has a term for the salience of features, but this is not carried out further. The present model could be used in future to fill this term. In contrast to automatic selection of salient features, current commercial navigation services construct their wayfinding directions from distances, orientation, and street names; some of them include pre-selected landmarks or points-of-interest[1]. The selection criteria of points-of-interest within these services are not transparent; hence we assume their selection process is not based on a cognitively plausible model. With cognitively plausible salient features one can expect a better success rate in wayfinding with a smaller cognitive workload.

This chapter, as the previous papers, does not discuss the communication of the selected features, i.e., the ways they are used in wayfinding directions.

3 Focalizing in Route Piloting

In the above described model, overall salience is introduced as a weighted mean of the individual scores of its visual, semantic, and structural qualities. However, salience is not a global property. People choose different features as references when they are in different decision situations. Their focus of attention is different, and thus, we need a method to *focalize*—to change between foci or select a specific focus—when providing route directions. Focalization will be investigated in this section, and the next section will approach it by weighting the measures of salience.

In the earlier paper [16], the model of salience of façades was developed within a specific decision situation: "Assume that you are spending a few days as a tourist in Vienna. You have just enjoyed a cup of coffee in one of the traditional coffee houses, the *Café Diglas*, and you start thinking about dinner. Your tourist guide recommends one of the current in-restaurants, *Novelli*. Unfortunately, what you get is only the address, not the shortest or any other route from the *Café Diglas* to *Novelli*. This is a typical scenario for a navigation service, a special case of a location-based service. Calling the service should provide a route guide, delivered in real time and tailored for the user's needs, in our case a pedestrian." (p. 243). The human subjects in the test were asked to imagine this situation when ranking the façades at intersections.

The necessity to describe the decision situation with that detail, i.e., the expectation that people focalize according to the decision at hand, gives reason to design a model that adapts to specific decision situations as well. People will focalize for the simple reason that in different situations the environment offers different affordances [9, 17]. Thus the above description of a decision situation is interesting with regard to

[1] See for example: http://www.blaupunkt.com.au/3.asp, http://www.mapquest.com, and http://www.whereis.com.au.

three aspects: it specifies (a) the mode of travelling: pedestrian, (b) the role of the traveller: tourist, and (c) the environment: dense urban area. It does not mention (d) the aspect of individual spatial and cognitive abilities of people, which are different in general and should be included as well.

Mode of travelling

Travelling as a pedestrian implies a certain perspective on the environment, a certain set of concepts of spatial features in focus, and, as a function of speed, a certain level of detail of perceptions. All of these are functionally dependent on the types of actions a pedestrian performs to solve the wayfinding task. A pedestrian moves in the street network with relative freedom, being not forced to stay on lanes or in directions. However, decisions how to proceed occur mainly at street intersections. In wayfinding directions for pedestrians, a single street intersection is referred to by salient features such as façades. These are features of spatial granularity similar to intersections, which form—if salient—a unique reference to an intersection, and are better to distinguish than the intersections themselves.

A different mode of travelling changes both visual perspective and focus [19]. A traveller in the subway conceptualizes the urban space in the form of lines that link places. Actions of a subway traveller are staying on board, transferring between lines, and leaving the subway network. The travel speed is too high to make decisions only at decision points, therefore other things come into focus, such as the names of stops, displays in the subway, and announcements.

Role of the traveller

The role of a traveller determines her focus, too. A tourist will in most cases be unfamiliar with the place, and thus paying attention to her environment. One might argue that a tourist performs wayfinding with a preference on visual clues, including visible semantic clues (signs), whereas structural qualities of a feature do not play a major role. In contrast, the attention of a person with some familiarity of the place, but in a hurry and therefore looking for the shortest route using a navigation service, is more focused on the network and its connectivity, and less on the visual attraction of the environment.

This argument refers to the fact that the two wayfinding problems are different: a tourist searches for attractive or scenic routes, whereas a local person looks for a time optimal route. Focus is related to the task at hand.

Environment of the traveller

The environment of the traveller offers clues to support the wayfinding task. In a dense urban area one can assume that sufficiently many façades are located at each intersection to identify a salient one. In loosely built-up areas, in areas where front gardens separate façades from the immediate environment of travellers, or in rural areas the role of façades as reference features diminishes, and other feature classes, such as signs and landscape features come into focus.

Another factor is time. Consider a dense urban environment: visual clues, and hence, salience, depend on the time of the day. At daytime, travellers perceive any visual quality, but in the evening or at night only illuminated parts of the environment can be perceived. Illumination might change over time, and is itself a function of the built-up structure. A department store is illuminated during shopping hours, a cultural landmark is illuminated until late in the evening, and main streets are illuminated until dawn.

Spatial and cognitive abilities of the traveller

People's spatial abilities seem to depend mainly on four interactive resources: perceptual capabilities, fundamental information-processing capabilities, previously acquired knowledge, and motor capabilities [1]. These resources support different wayfinding means. Resource limitations within different groups of people such as handicapped people or people of different age have a definite impact on the success of wayfinding. As for the spatial abilities, the cognitive abilities also depend on the task at hand. Finding one's way in a street network [20] uses a different set of cognitive abilities than navigating from one room to another in a building [8].

Differences in abilities of travellers lead to a change of their foci of attention. The average tourist can spend undivided attention to the visual attraction of her environment, while a handicapped tourist is distracted by getting over various obstacles in the environment. A blind tourist finds her way by using other senses than the visual one. Similar considerations will require taking into consideration the age of the traveller, her personal experience or wayfinding strategies, and her degree of local knowledge.

Without claiming to be complete, the discussion of these aspects defining a decision situation shows that any factor in the situation could require an adaptation of the proposed model of salience. If people focalize, the automatic selection model needs the same ability with the same behaviour. There are three degrees of freedom in adapting the model: one can choose (a) other feature classes than façades, (b) other measures for visual, semantic, and structural qualities, or (c) other weights for these measures. In this chapter we will focus on the third option. This means that in the following we do not change the environment and consider only the mode of walking on the surface of the earth. Then a change of weights allows some adaptation to different situations.

4 Focalizing by Weighting the Measures of Salience

Weights seem to be one key to focalization, according to the previous discussion. In this section we will show the relation between weights of measures and focalization.

We investigate the possibilities of modifying the weights, and the theoretical expressiveness of doing so.

Determining salience with adaptive weights is computationally feasible if the weights are constant for a specific focus. The expensive part is computing the measures for each feature from its qualities. Let us assume that these measures (currently seven) are available for each feature [see 15]. Then one can determine the overall salience of each feature on the fly, by summing up seven multiplications of measures with their weights.

The basic assumption is that a specific focus is reflected by a constant, global set of weights. This means it is expected that people consistently use a set of weights when choosing landmarks along a route for a specific mode of travelling, role of the traveller, environment, and specific abilities and preferences of the traveller. The assumption will be tested in the next section.

Under this assumption there are several strategies to determine a set of weights for a specific user group or individual: (a) reasonable assumptions of the service provider, (b) specifications by the user, (c) by learning from real behaviour. In principle, all these strategies can be run discretely, leading to Boolean weights or subsets of measures, or continuously, leading to weighted measures of finer differentiation.

Specifications by the provider

The provider can specify a set of weights for each focus she wants to cover in her portfolio. Staying with Boolean weights this means a selection from the given set of measures, turning off other measures. Continuous weights allow a finer differentiation.

Let us assume that the service provider misses for an area some datasets that are necessary to calculate the given measures. The provider can decide to go without these measures, setting their weights explicitly to '0', instead of delivering flawed results or searching for the missing data in third-party databases.

In Nothegger [13] the weights for all visual attractions are set equal, and also the weights for all semantic attractions. But not all the measures are of the same importance for the overall salience. This observation comes from the fact that not all measures produce the same spectrum of results: where some qualities occasionally appear to be salient, others might never. The set of never salient qualities might change in areas with other characteristics, however, for specific areas one might decide to turn off some measures on principle, to save the costs of computation.

Besides the provider perspective, considering availability or profitability of measures, the provider can take the user's perspective. In this case she wants to specify the weights according to the focus of the user. If, for example, experience teaches that a specific weight set is successful for a specific region or a specific homogeneous user group then the service provider can offer differentiated sets of measures. However, there is no obvious relation between focus and weights that would allow specifying the measures in a straightforward way. The only strategy is by trial and error, where specified weights could be adapted later on the basis of feedback.

Specifications by the user

The provider can ask the user of a service for her preferences. From introspection, a user might choose to be guided only by visually salient qualities, or only by semantically salient qualities. This is again realizable with Boolean weights, or gradually by continuous weights. However, the user might start with an arbitrary set and adapt it later on the basis of satisfaction. In addition, her focus might change, such that the complexity through the degrees of freedom explodes.

A more realistic model is to let the user choose a focus from a given list, if it cannot be determined automatically. Each focus would be linked to a set of weights, which leaves the problem of determining such a set.

Learning from behaviour

People can be observed when they select features as landmarks for given decision situations. Large samples of triples {*focus*, *location*, *selection*} will allow identifying weights that reflect best people's behaviour, if the test area is sufficiently discriminative. Having identified a set of weights for a specific focus, this set can be applied outside of the training area. If needed, a feedback loop can be established to further improve the weights.

With this approach other investigations can follow. The standard deviation of matches between people's selection and the identified set of weights is a measure for the narrowness of the focus, or of consistent behaviour among a group of persons. A sensitivity analysis may demonstrate how variations of single weights influence the overall salience of the features. It may also tell how separable the different foci are.

5 Test of Weighted Salience

To investigate whether different focalizations can be represented by different sets of weights for the salience measures, we conducted a human subject test that focused on people's landmark selection during wayfinding by day and night (first part of the test), and on the differences in measures used for the two conditions (second part of the test). We addressed several issues in this study: What are the differences in landmark selection between different user groups (with respect to age, gender, familiarity with the environment)? What are the differences in landmark selection between wayfinding in daylight and in the night? What is the relative importance of each salience measure? Can these differences be modelled through weights for the given criteria?

Participants had to fill out an interactive web-based questionnaire. First, each subject was asked to specify age, gender, and familiarity with Vienna's central district. In the first part of the test, subjects were shown 360° panoramic images of four intersections in an interactive viewer. These intersections form a subset of the material for the test mentioned earlier [13]. The user had the possibility to either look at the rotating image or change the view manually by moving the mouse in various directions. The temporal aspect of the situation was chosen randomly. Half of the participants were faced with the daylight images, the other half was presented the same intersections but photographed at night. Subjects were not informed about this duality of the test. The following question was asked for each intersection: “Which of the façades do you find prominent according to its characteristics? Assign 10 points overall. The more exceptional the characteristic, the more points. 0 points = not exceptional.” (Fig. 1).

Fig. 1. Screen shots from the survey: scene from an urban panorama by night and by day (the subjects have seen either the night scene or the day scene). The subjects should distribute 10 points between the seven facades of this intersection.

The second part of the test focused on finding out which of the given five salience measures (area, shape, colour, visibility, and signs) subjects used to decide on the prominence of a façade. In addition, sketches for the measures were given for clarification of the terms (Fig. 2). The following question was asked: “Rank the following façade characteristics with regard to their importance of singling out one façade against another (1 = most important, 5 = least important).” Finally, subjects had the possibility to name additional criteria and write down comments.

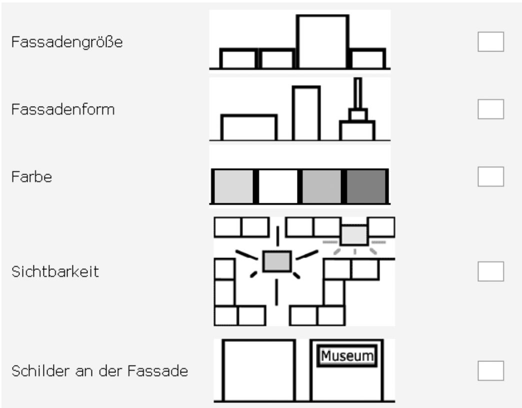

Fig. 2. Screen shot from the second part of the survey: ranking of five salience measures (from top: area, shape, colour, visibility, and identifiable use). Subjects should rank them.

Participation in the survey was anonymous, voluntary, and unpaid. The link to the questionnaire was distributed broadly to students, colleagues and friends, and the data was collected during December 2003. According to the distribution channel the majority of the participants were relatively young: 67% were under 29 years old, and 79% under 39. In total, 92 complete datasets were received (Table 1).

Table 1. Distribution of the 92 valid and complete datasets.

Gender		**Age**				**Familiarity**		**Scene set**	
f	*m*	*-29*	*-39*	*-49*	*>50*	*n*	*y*	*day*	*night*
31	61	62	11	8	11	60	32	45	47

6 Results

The results from the above survey were subject to statistical testing. Several hypotheses were tested, regarding whether people choose different landmarks by day than by night, whether they apply different criteria, and whether the differences in behaviour can be mapped to weighting of measures. Here the findings are reported.

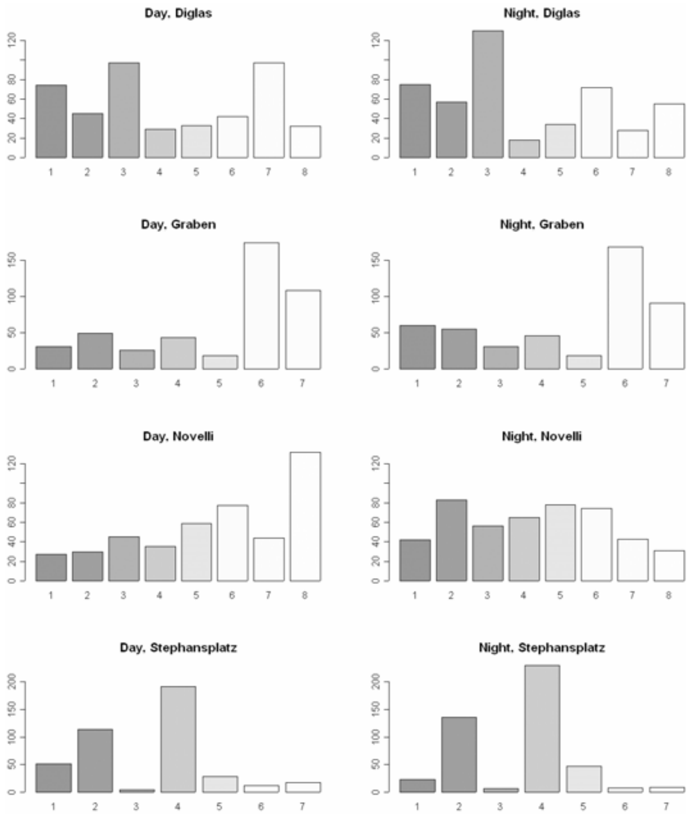

Fig. 3. Total scores of the façades at four street intersections, at day and night.

The first investigated question is: Are choices of landmarks different between day and night? It turns out that for several façades the total score at daytime is significantly different from the score at night. This is visible in Figure 3: While, in the 'Diglas' scene, at day the façades 3 and 7 are comparably prominent, at night the score for façade 3 boosts. In the 'Novelli' scene, the ranking even inverts: While at day the façade 8 is the most prominent, at night it does attract the least attention. Instead façade 2 becomes prominent at night, which does not attract at daytime. The question can be answered positively: people choose different landmarks at day and night.

Further it can be studied whether there exist gender differences in scoring the façades. A multi-factor variance analysis shows significant differences in the perception of female and male subjects. In Figure 4, the results are demonstrated with selected façades for the two factors *daytime* and *gender*. In some cases, the gender difference cannot be overlooked (e.g., 'Bräunerstrasse 9'), in other cases the perception of the genders is different more at daytime or in the night (e.g., 'Wollzeile 6-8', 'Wollzeile 11', 'Stock-im-Eisen-Pl 4'), and again in other cases there are no remarkable gender differences (e.g., 'Stallburggasse 1'). Other factor combinations appear significant, too, but in these cases the sample sizes are too small to yield reliable results.

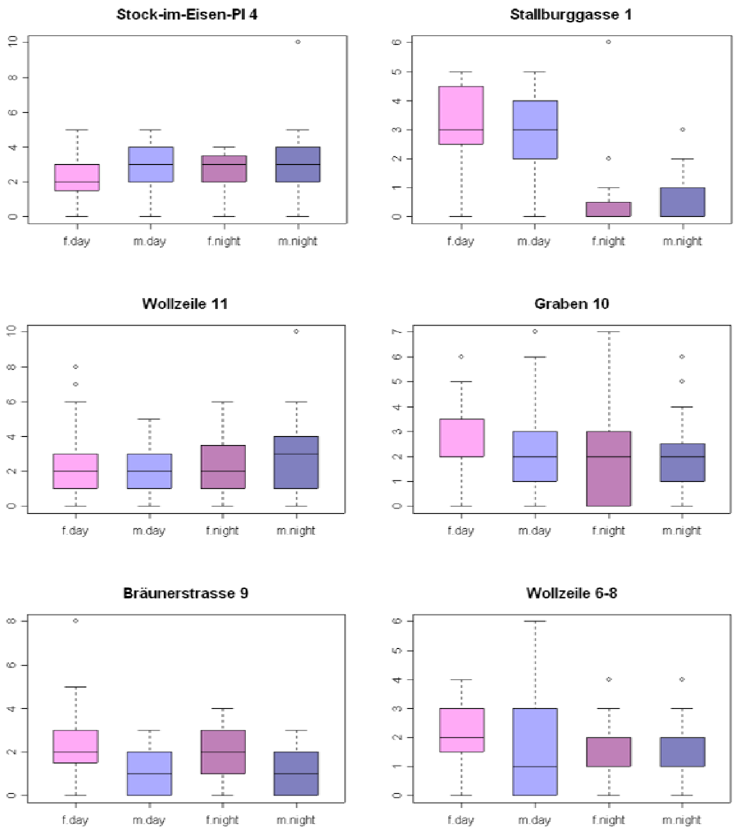

Fig. 4. Gender differences in scoring selected façades by day and by night (*y*-axis: score 0…10). The boxes show the median score and its interquartile range for the individual groups.

The following investigations concern the second part of the questionnaire: the ranking of the criteria. Here, the most interesting question is whether the ranking of the criteria is dependent of the time of the day. A variance analysis with the two factors *daytime* and *criterion* shows a *P*-value of 0.1: it is just under the significance level. Although not significant, some differences between the rankings of the criteria according to daytime exist: at night, façade area and visibility lose, and use of the building gains. However, the rankings of the criteria support the hypothesis that not all criteria are of the same importance. Figure 5 shows the rankings with a scale from 1 (not relevant) to 5 (most relevant). The semantic criterion, identifiable use of the building, is significantly ranked lowest. Visibility turns out to be the significantly most prominent criterion. The others ranked approximately equally. These results do not harmonize with the intuitive scorings given in part 1, as will be shown next.

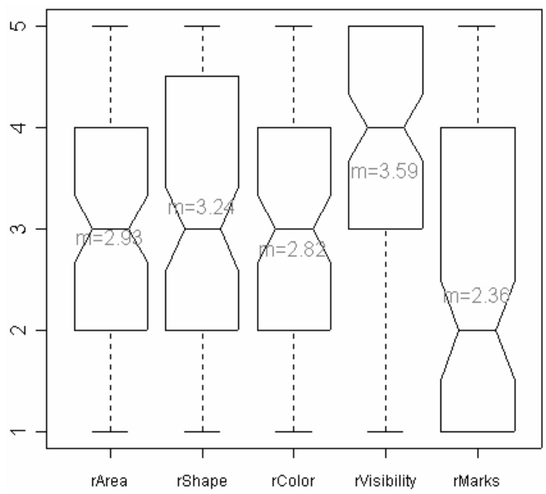

Fig. 5. Median rankings (*y*-axis: rank 1…5) of the five criteria façade area, façade shape, façade colour, façade visibility, and identifiable use of the building.

The final question is how weights of criteria determined from the scoring of the buildings in the first part of the questionnaire correlate to the ranks of the criteria given in the second part of the questionnaire. Weights were calculated by a regression approach with a robust estimator, separately for day and night. The results are given in Table 2.

Table 2. Weights for the criteria façade area, shape, colour, visibility, and discernible use of the building, determined from the scoring of the buildings in part 1.

	Area	**Shape**	**Color**	**Visibility**	**Marks**
Day	0.11	0.15	0.37	0.26	0.12
Night	0.26	0.0	0.21	0.23	0.30

The multiple regression coefficient is significantly different from 0, which means there is a significant correlation between the criteria (predictors) and the ranking by the subjects (response). However, there is no correlation between the determined weights of the criteria (Tab. 2) and the rankings of the criteria by the subjects (Fig. 5). The weights show some influence of the criteria colour and visibility, accompanied by night by the discernible use of the building. Further, compared to the ranking of the criteria, there is a significant difference between weights at daytime and at night.

7 Conclusions and Outlook

The chapter discusses the possibilities to model different foci onto urban space by weighting visual and semantic salience criteria, and it investigates the proposed method in a thorough human subject test. With the design of the survey we could investigate first steps of a focalization. Staying within a specific user group, only one factor was varied, the time of the day. The factor varies the perception of the urban environment. We found evidence that this variation already changes the behaviour of the users—they select different landmarks—, and that the variation of behaviour can be modelled by a different weight set for the automatic selection of salient features. The latter was statistically significant and acceptable in its explanatory power, but not completely satisfying. It is subject to future research whether this result can be confirmed in cases of larger variations of the focus of influence. It is also subject to future research whether other criteria can be identified that would increase the explanatory power of different weights.

It could be observed that people choose landmarks without being (too) conscious about the selection criteria. The ranking of the criteria we asked for in part 2 is not correlated with the focus (here: time of day), although the subjects chose different landmarks. Furthermore, the ranking is different from the weights calculated by regression analysis. We assume that the ranking result, especially the highest ranked visibility, is influenced by the survey design. Subjects being asked to rank criteria might have had the last decision situation in memory, which was a strong case for visibility (St. Stephen's Cathedral). We also assume that the rank of the only semantic criterion, discernable use of the building, is distorted. Comments from subjects let us suppose that the wording in this case was taken too literally ("Schilder an der Fassade": marks on the façade), and thus, distorts the relative ranking. The weight of this criterion, derived from the real selection behaviour of the subjects, is noticeably higher, especially by night.

Future research will show whether different sets of weights can be determined and recommended for different foci of wayfinders. It is uncertain whether the different weights we have found can be reproduced at other street intersections, and therefore we refrain from proposing them as a universal set of weights in the sense of [24]. However, the change of the weights seems reasonable for this change of the focus: the increased influence of the semantic criterion makes sense because it is related to the illumination of the building. The decreased influence of the criterion shape at night is reasonable because the shape of a building gets lost in darkness.

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